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GOODYEAR AEROSPACE CORPORATION

AKRON 15, OHIO

PARAMETRIC STUDY OF DYNAMIC LIFT
AEROSTATS FOR FUTURE NAVAL MISSIONS

GER 13564

January 31, 1968

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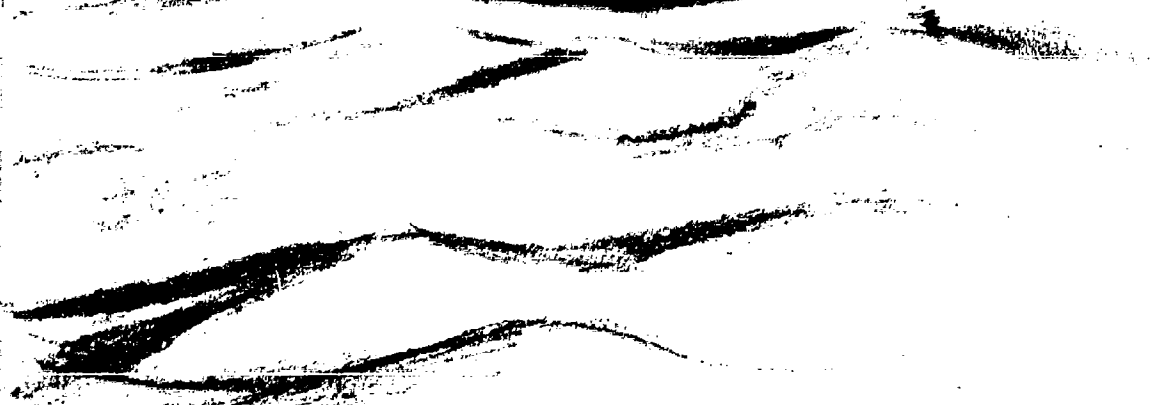
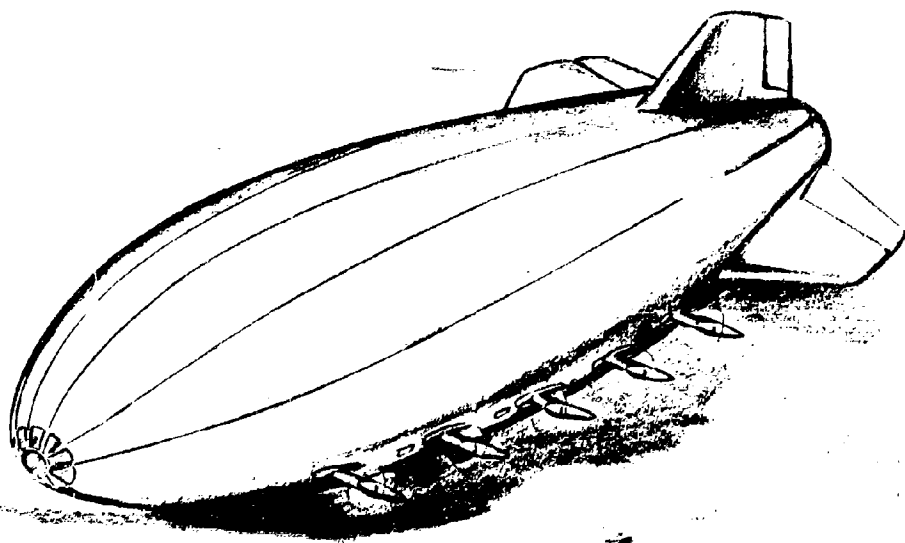
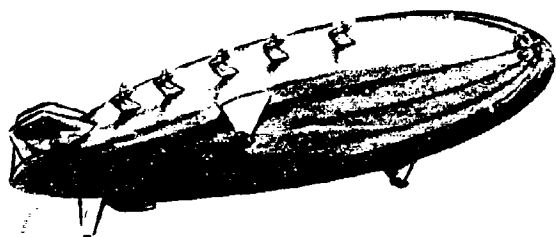


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LIST OF SYMBOLS

a	acceleration - ft/sec^2
A_D	drag area - ft^2 - ($A_D = C_D V^{2/3}$) or (frontal area $\times C_D$)
APU	auxiliary power unit
BHP	brake horsepower
BSFC	brake specific fuel consumption - lbs/BHP/hr
C_D	drag coefficient - ($C_D = D/qV^{2/3}$) unless otherwise defined
C. B.	center of buoyancy
C. G.	center of gravity
C_L	lift coefficient - ($C_L = L/qV^{2/3}$)
\bar{C}	center line
C_p	power coefficient
D	drag - lbs
D	diameter - ft
F. F.	fuel flow - lbs/hr
F. R.	fineness ratio = length/maximum diameter
G. R.	propeller gear ratio
H	heaviness - lbs [initially = $(1 - L_s/W_o)W_o$]
h_3	design altitude - ft
h_2	intermediate altitude
h_1	1500 ft
I_Y	polar moment of inertia about the pitching axis - slugs ft^2
K	coefficients as designated
L	envelope length - ft
L_s	static lift - lbs
N_E	number of engines
N. R. P.	normal rated power
n	propeller rpm
q	dynamic pressure - lbs/ft^2 - ($q = 1/2 \rho v^2$)
q	angular velocity radians/second
R. N.	Reynolds number - vL/ν
RPM	revolutions per minute
S_w	wetted area
T	thrust - lbs
t	time - hours

V_K	velocity in knots
V_{max}	design speed at normal rated power - knots
$V_{MIN\ BHP}$	velocity for greatest endurance - knots
$V_{max\ range}$	velocity when V/BHP = minimum - knots
v	velocity - ft/sec
v_{TO}	take-off velocity - ft/sec
v_w	surface wind - ft/sec
VTOL	vertical take off and landing
∇	envelope volume - ft ³
$\nabla^{2/3}$	volume ^{2/3} - ft ²
$\nabla^{1/3}$	volume ^{1/3} - ft
W_o	gross weight - lbs
$W_{F + PL}$	fuel + payload weight - lbs
W_1	$W_o - .25 (W_F + PL)$
W_2	$W_o - .50 (W_F + PL)$
W_3	$W_o - .75 (W_F + PL)$
α	angle of attack - degree (radians in stability section)
ν	kinematic viscosity of air - ft ² /sec
η	propeller efficiency
θ	pitch angle - degrees
μ	coefficient of wheel friction
ρ	mass density of air - slugs/ft ³

SUMMARY

Future airships through gross weights of 100,000 to 1,500,000 pounds (displacements of 1,100,000 to 44,000,000 cubic feet), design speeds of 70, 140, and 210 knots, and design altitudes of 5,000, 10,000, and 20,000 feet are studied in this report.

In the 70-knot design range, minimum horsepower requirement and maximum payload are achieved with essentially neutrally-buoyant flight. Some penalty in installed power plant weight can be accepted for better specific fuel consumption if maximum range and endurance are the primary design considerations.

At 140 knots and higher, minimum horsepower and maximum payload are generally achieved with a combination of dynamic and static lift.

The optimum ratio of static lift to gross weight (L_s/W_o) is primarily a function of design speed and gross weight, and the relationship of induced drag and basic form drag of the specific airship configuration.

At 140 knots and higher the horsepower requirements dictate greater consideration of installed power-plant weight rather than emphasis primarily of minimum fuel consumption. Turbo-prop power offers greatly increased payload capability to that available with reciprocating or diesel engine power.

At 70-knot design speeds, only nearly-buoyant ships inherently have vertical take-off capability. At 140-knot design speeds, ships of $L_s/W_o = 0.9$ and 0.8 have vertical take-off capability, depending upon type and gross weight.

In the 210-knot regime L_s/W_o ratios smaller than the 0.6 studied are undoubtedly capable of greater payloads and lesser power requirements in the gross weight range of this study.

Further investigation of the pressurized metal airship appears promising as leading to lower structural weights.

More sophisticated wind-tunnel investigations of configurations for minimal total drag throughout the total design flight regime are indicated, for further development of the dynamic-static lift airship concept.

SECTION I - INTRODUCTION

This investigation is a parametric performance study of the capabilities of future large airships into the 1980 period. It is a considerable extrapolation from past actual constructions as to physical size and gross weight, speeds, and altitudes. Previous airships reached weights of 400,000 pounds, speeds of 80 knots, and normal altitudes of 5-10,000 feet. This study covers gross weights to 1,500,000 pounds, speeds to 210 knots, and design altitudes of 20,000 feet. It also examines the possibilities of a combined static-dynamic lift configuration as contrasted with the all-static lift airship of the past.

The weights figures of Appendix A are based on compilations of actual airship weights. Extrapolations involved optimistic expectations of improvements in available strength-weight ratios. This is particularly true of coated fabrics which constitute a large part of the structural weight of non-rigid types. For the larger, faster ships studied it was felt that the elastomeric coating would not represent as high a proportion of total fabric weight as heretofore.

The data for non-rigid airships is extrapolated from fairly recent data, the last Naval "blimp" having been built in the 1960-61 period. Rigid airship data dates from the early 1930's. It is believed that because of the gap in development rather less optimism has been applied to this specific data than to that for the non-rigid. The extrapolations of the rigid may, therefore, result in somewhat greater structural weights than might actually be achievable with up-to-date materials, methods, and engineering. If this is so, the cross-over in payload capability would occur at lower gross weights and sizes - favoring the rigid sooner than seems to be the conclusion of this study.

SECTION II - ALL STATIC-LIFT AND "DYNASTAT"
(DYNAMIC-STATIC LIFT) VEHICLES

The airship as it has previously been configured is a powered, streamlined body-of-revolution air-displacement vehicle deriving its buoyancy from the difference in weight of the helium gas within its hull or envelope and the weight of the ambient atmosphere thus displaced. Dynamic forces were used primarily for control and maneuvering, with very little deliberate exploitation of dynamic lift forces to sustain "heaviness".

Two distinct structural types gave rise to a definition of dirigibles* based on this difference:

rigid, or unpressurized, airships; (Zeppelins)
non-rigid, or pressurized airships (Blimps).

A third type, semi-rigid, is a blend of these two.

The rigid types such as the "Akron", "Macon", and "Hindenburg" were built up of bulkhead rings, transverse girders, and a network of pre-tensioned diagonal shear wires. An outer fabric cover provided a wind and weather cover. Lifting gas was contained in several independent gas-tight cells, supported between bulkhead ring nettings. The gas cells were partially filled at sea-level, pressure height by definition being the altitude at which expansion of the gas completely filled the cells. Climb beyond pressure height necessarily required the valving and irrevocable loss of helium to prevent over-pressuring and rupture of the cells. Large poppet valves were provided with automatic spring settings for over-pressure protection. Manual valving was also possible.

The non-rigid or pressure airship consists of a hull of coated fabric filled with helium and pressured slightly above ambient. Several ballonets, or air compartments, are curtained off within the envelope. They are normally located

*dirigible, n. Specif. A lighter-than-air aircraft having its own motive power, which may be steered in any desired direction by its crew. Attrib. with hangar. dirigible, a. Of aircraft or airborne devices: That can be directed or steered. dirigible balloon. A balloon, esp. a nonspherical balloon, that can be steered. U.S. Air Force Dictionary, 1956, no specific structural type is implicit in the term "dirigible".

forward, aft, and amidships. The maximum ballonnet capacity is a function of the design pressure height.

Pressurization of the envelope is accomplished by scooping air for the ballonets from the propwash or pumping with electric blowers through an air distribution system to the ballonets. Dampers, air lines, and exhaust valves at the ballonets permit both control of envelope pressure and relative fullness of fore-and-aft ballonets for trimming in pitch. As the ship ascends expansion of the helium is permitted without loss of gas by deflation of the ballonets. Pressure height is the altitude at which the ballonets are completely deflated, the envelope at that point being 100 percent full of helium. Further ascent could only occur with valving of helium. It is possible for a ship to be flown so high, with consequent valving of helium, that upon descent the ballonets are pumped full before the ground has been reached. Further descent, with envelope pressurization, can only be accomplished then by pumping air directly into the helium provided an emergency access of air line to helium is provided.

Rate of ascent with a pressure airship may be limited by engine power - if the ship is "heavy" - but is structurally limited by the ballonnet valves' capacity to exhaust air. Conversely, rate of descent is limited by the air system's capacity to pump air into the ballonets as the helium contracts with increasing ambient pressure.

Car structure and engine nacelles on a rigid airship are extended from convenient bulkhead rings and longitudinal girders. On a non-rigid, the car structure weight is distributed to the fabric envelope by means of several catenary systems. Usually two identical internal catenary curtains, either side of C on the top of the envelope, tie to the upper envelope along two fore-and-aft "Y"-joints. Vertical tension cables from the roof of the car carry weight to fitting points on the curtains. The curtains spread the load to the upper envelope, deforming it slightly out-of-round at the "Y" intersection. A catenary system around the car-lower envelope intersection distributes pitching or yawing loads to the envelope. Fins on a non-rigid are cable-braced to finger patches tangent to the cable-envelope intersections. Power plant installations on a non-rigid have always been extensions from the hard car structure.

The semi-rigid airship generally differed from the non-rigid by utilizing a nose-to-tail rigid keel rather than the catenary curtains for distributing car weight to the fabric envelope. It was still a pressure airship, requiring slight pressurization to permit resistance of hull bending moments without envelope wrinkling. Its cross-sectional shape tended more to a pear-shape because the entire car weight was applied to the bottom of the envelope.

The large rigid airships maintained neutral buoyancy, as fuel weight diminished, by manufacturing water ballast from the engine exhausts. Suitable radiator equipment condensed the moisture in the hot exhaust gases and the condensate could be stored in the emptied fuel tanks. If sufficient radiator capacity is provided an excess of ballast is available.

The smaller blimps reballasted by picking up sea-water to be stored in emptied fiberglass fuel tanks. Since helium costs \$35.00/1,000 cubic feet and 1,000 cubic feet will lift 63 1/2 pounds, the cost of valving helium to compensate for excess lift is on the order of \$0.55 per pound of "lift", obviously a considerable cost for a sizable fuel weight burn off.

The DYNASTAT concept proposes to reduce the size of a given gross weight ship, simplify ground handling, and reduce the ballasting requirements by deliberately flying appreciably "heavy". Since the conventional airship form - a streamlined body-of-revolution - is a relatively poor airfoil, the apparent approach to a DYNASTAT is a flattened, low-aspect ratio, helium-filled envelope. Goodyear Aerospace's first lobed concept (Envisioning a pressure airship type) was the subject of wind tunnel testing reported in References (3) and (4). Data from these reports are the basis for performance quoted on the DYNASTAT in this report.

Physical dimensions of rigid and non-rigid airships for fineness ratios indicated are presented in Figure 1, DYNASTAT dimensions conforming to the wind tunnel models are given in Figure 2. Required airship volumes, either DYNASTAT or conventional are given in Figure 3 as a function of W_0 , h_3 , and L_s/W_0 ratio. The "wing-loadings" of "heavy" conventional non-rigids or DYNASTATS of the Reference (3) and (4) model are given in Figure 4. Four approximately comparable ships are illustrated in Figures 5 through 8.

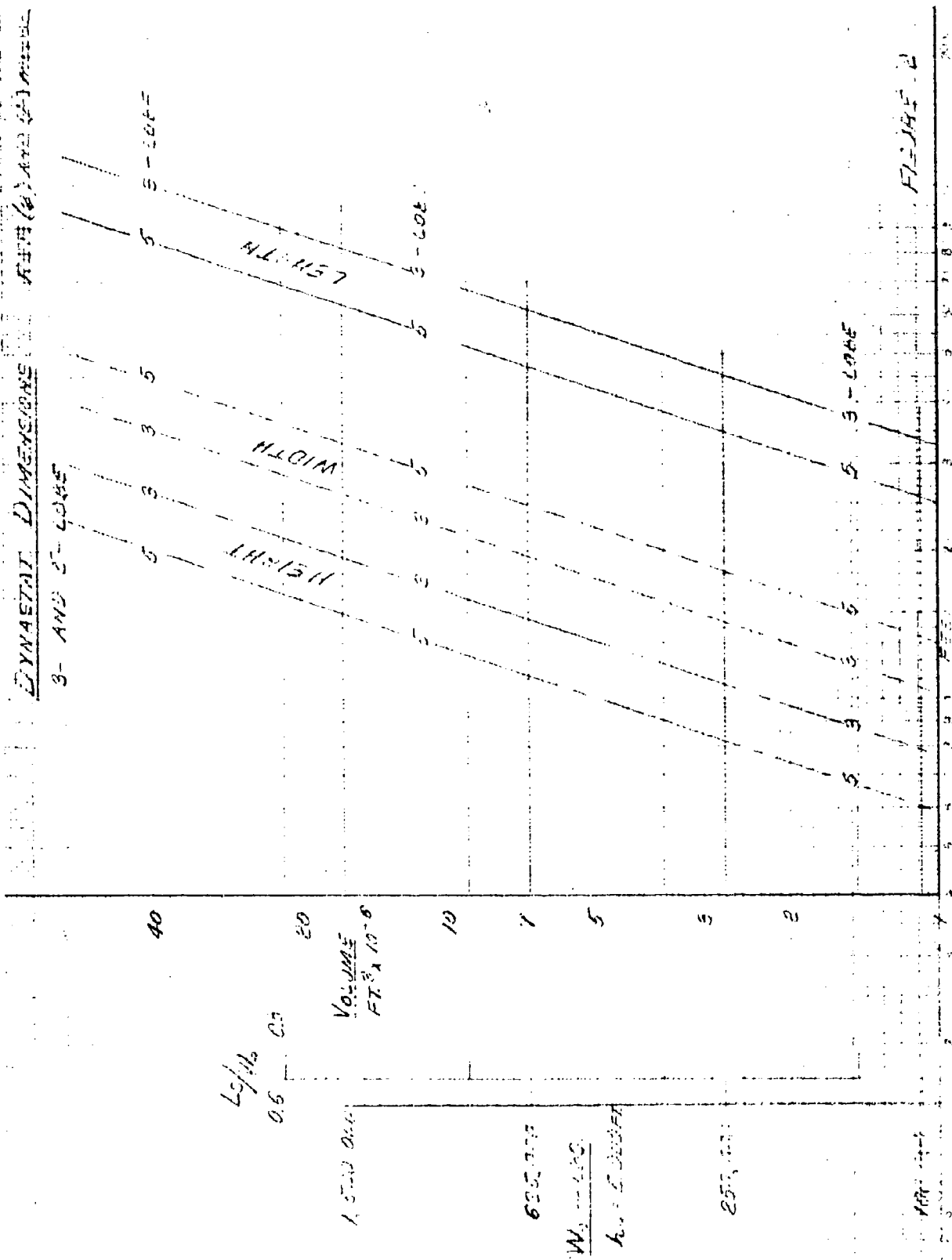
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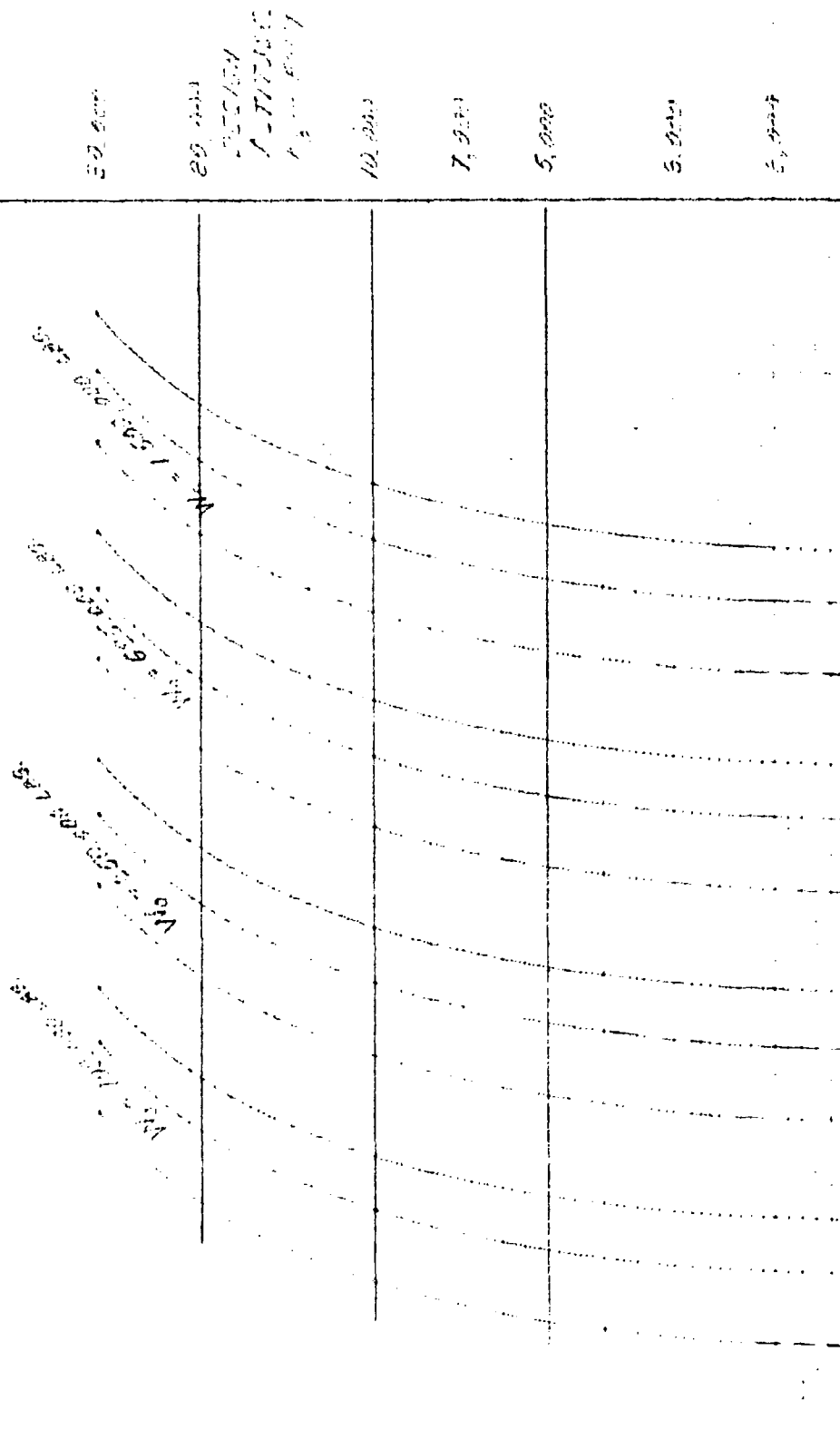
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BASED ON LIFT OF
AIRPORT AT 0.0635 LBS/FT³
RIGIDS ARE 107% OF NON-FUSID



1915-16-17-18-19-20-21-22-23-24-25-26-27-28-29-30-31-32-33-34-35-36-37-38-39-40-41-42-43-44-45-46-47-48-49-50-51-52-53-54-55-56-57-58-59-60-61-62-63-64-65-66-67-68-69-70-71-72-73-74-75-76-77-78-79-80-81-82-83-84-85-86-87-88-89-90-91-92-93-94-95-96-97-98-99-100-101-102-103-104-105-106-107-108-109-110-111-112-113-114-115-116-117-118-119-120-121-122-123-124-125-126-127-128-129-130-131-132-133-134-135-136-137-138-139-140-141-142-143-144-145-146-147-148-149-150-151-152-153-154-155-156-157-158-159-160-161-162-163-164-165-166-167-168-169-170-171-172-173-174-175-176-177-178-179-180-181-182-183-184-185-186-187-188-189-190-191-192-193-194-195-196-197-198-199-200-201-202-203-204-205-206-207-208-209-210-211-212-213-214-215-216-217-218-219-220-221-222-223-224-225-226-227-228-229-230-231-232-233-234-235-236-237-238-239-240-241-242-243-244-245-246-247-248-249-250-251-252-253-254-255-256-257-258-259-260-261-262-263-264-265-266-267-268-269-270-271-272-273-274-275-276-277-278-279-280-281-282-283-284-285-286-287-288-289-290-291-292-293-294-295-296-297-298-299-300-301-302-303-304-305-306-307-308-309-310-311-312-313-314-315-316-317-318-319-320-321-322-323-324-325-326-327-328-329-330-331-332-333-334-335-336-337-338-339-340-341-342-343-344-345-346-347-348-349-350-351-352-353-354-355-356-357-358-359-360-361-362-363-364-365-366-367-368-369-370-371-372-373-374-375-376-377-378-379-380-381-382-383-384-385-386-387-388-389-390-391-392-393-394-395-396-397-398-399-400-401-402-403-404-405-406-407-408-409-410-411-412-413-414-415-416-417-418-419-420-421-422-423-424-425-426-427-428-429-430-431-432-433-434-435-436-437-438-439-440-441-442-443-444-445-446-447-448-449-450-451-452-453-454-455-456-457-458-459-460-461-462-463-464-465-466-467-468-469-470-471-472-473-474-475-476-477-478-479-480-481-482-483-484-485-486-487-488-489-490-491-492-493-494-495-496-497-498-499-500-501-502-503-504-505-506-507-508-509-510-511-512-513-514-515-516-517-518-519-520-521-522-523-524-525-526-527-528-529-530-531-532-533-534-535-536-537-538-539-540-541-542-543-544-545-546-547-548-549-550-551-552-553-554-555-556-557-558-559-560-561-562-563-564-565-566-567-568-569-570-571-572-573-574-575-576-577-578-579-580-581-582-583-584-585-586-587-588-589-590-591-592-593-594-595-596-597-598-599-600-601-602-603-604-605-606-607-608-609-610-611-612-613-614-615-616-617-618-619-620-621-622-623-624-625-626-627-628-629-630-631-632-633-634-635-636-637-638-639-640-641-642-643-644-645-646-647-648-649-650-651-652-653-654-655-656-657-658-659-660-661-662-663-664-665-666-667-668-669-670-671-672-673-674-675-676-677-678-679-680-681-682-683-684-685-686-687-688-689-690-691-692-693-694-695-696-697-698-699-700-701-702-703-704-705-706-707-708-709-710-711-712-713-714-715-716-717-718-719-720-721-722-723-724-725-726-727-728-729-730-731-732-733-734-735-736-737-738-739-740-741-742-743-744-745-746-747-748-749-750-751-752-753-754-755-756-757-758-759-760-761-762-763-764-765-766-767-768-769-770-771-772-773-774-775-776-777-778-779-780-781-782-783-784-785-786-787-788-789-790-791-792-793-794-795-796-797-798-799-800-801-802-803-804-805-806-807-808-809-810-811-812-813-814-815-816-817-818-819-820-821-822-823-824-825-826-827-828-829-830-831-832-833-834-835-836-837-838-839-840-841-842-843-844-845-846-847-848-849-850-851-852-853-854-855-856-857-858-859-860-861-862-863-864-865-866-867-868-869-870-871-872-873-874-875-876-877-878-879-880-881-882-883-884-885-886-887-888-889-890-891-892-893-894-895-896-897-898-899-900-901-902-903-904-905-906-907-908-909-910-911-912-913-914-915-916-917-918-919-920-921-922-923-924-925-926-927-928-929-930-931-932-933-934-935-936-937-938-939-940-941-942-943-944-945-946-947-948-949-950-951-952-953-954-955-956-957-958-959-960-961-962-963-964-965-966-967-968-969-970-971-972-973-974-975-976-977-978-979-980-981-982-983-984-985-986-987-988-989-990-991-992-993-994-995-996-997-998-999-1000-1001-1002-1003-1004-1005-1006-1007-1008-1009-1010-1011-1012-1013-1014-1015-1016-1017-1018-1019-1020-1021-1022-1023-1024-1025-1026-1027-1028-1029-1030-1031-1032-1033-1034-1035-1036-1037-1038-1039-1040-1041-1042-1043-1044-1045-1046-10

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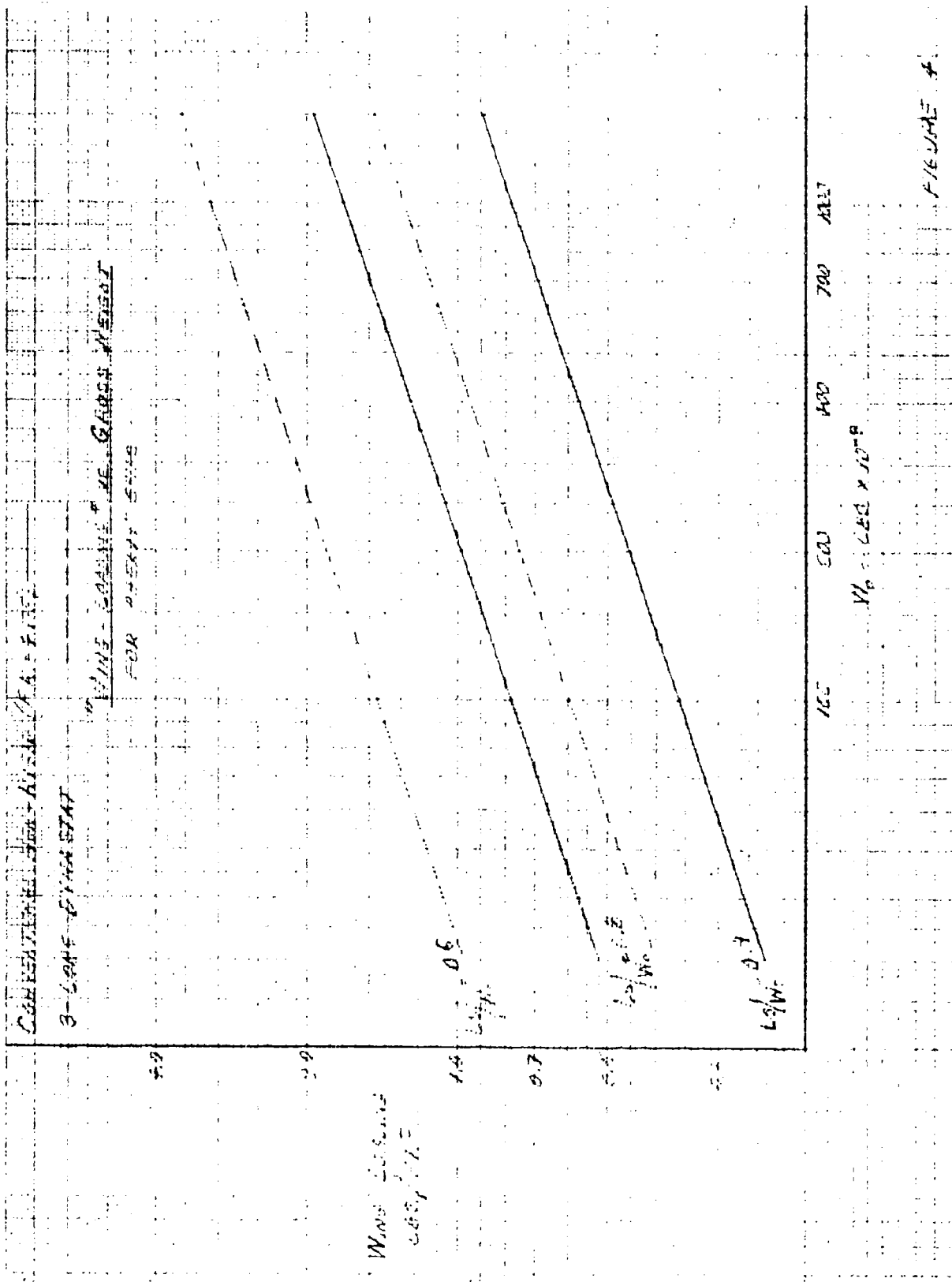
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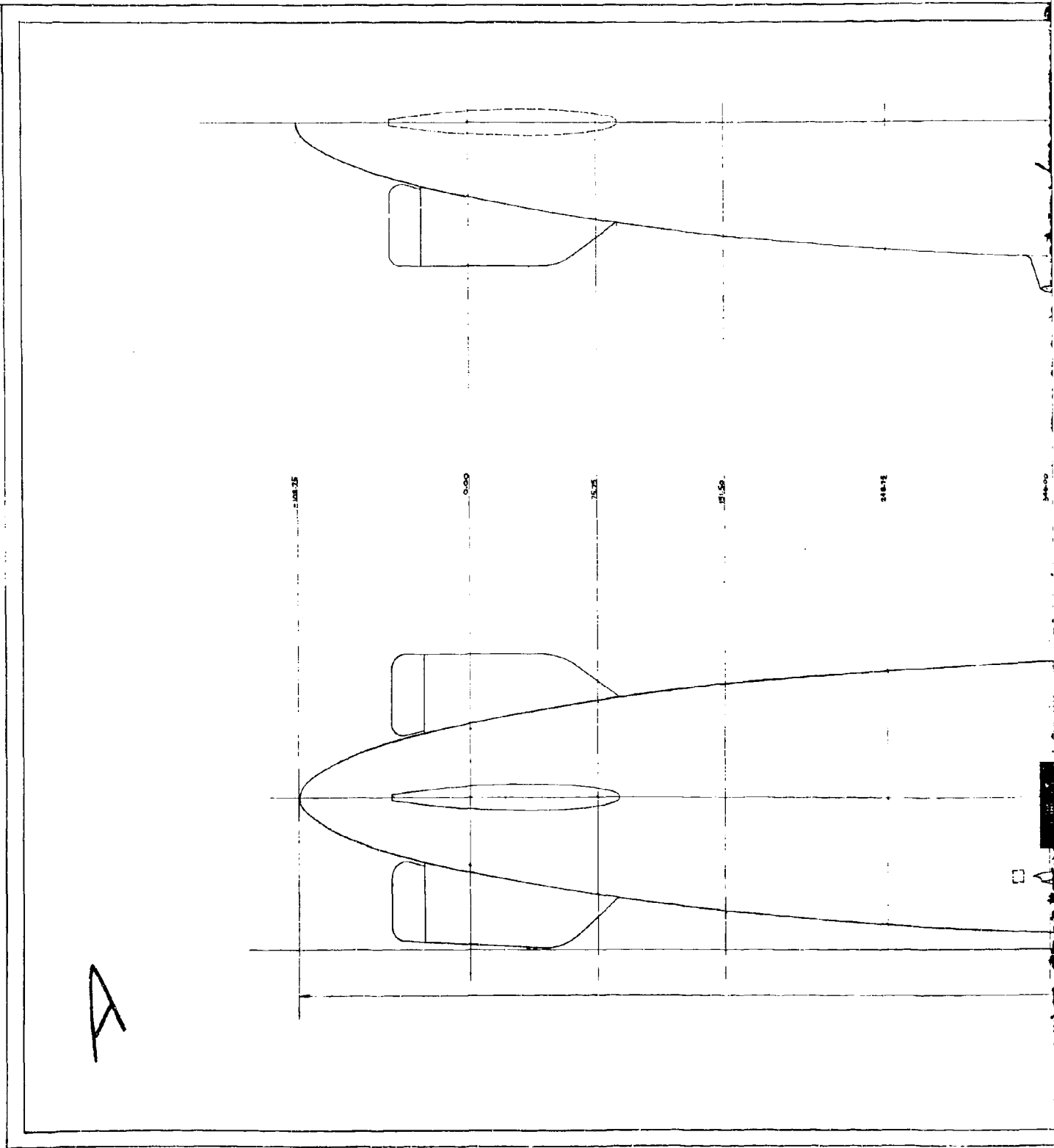
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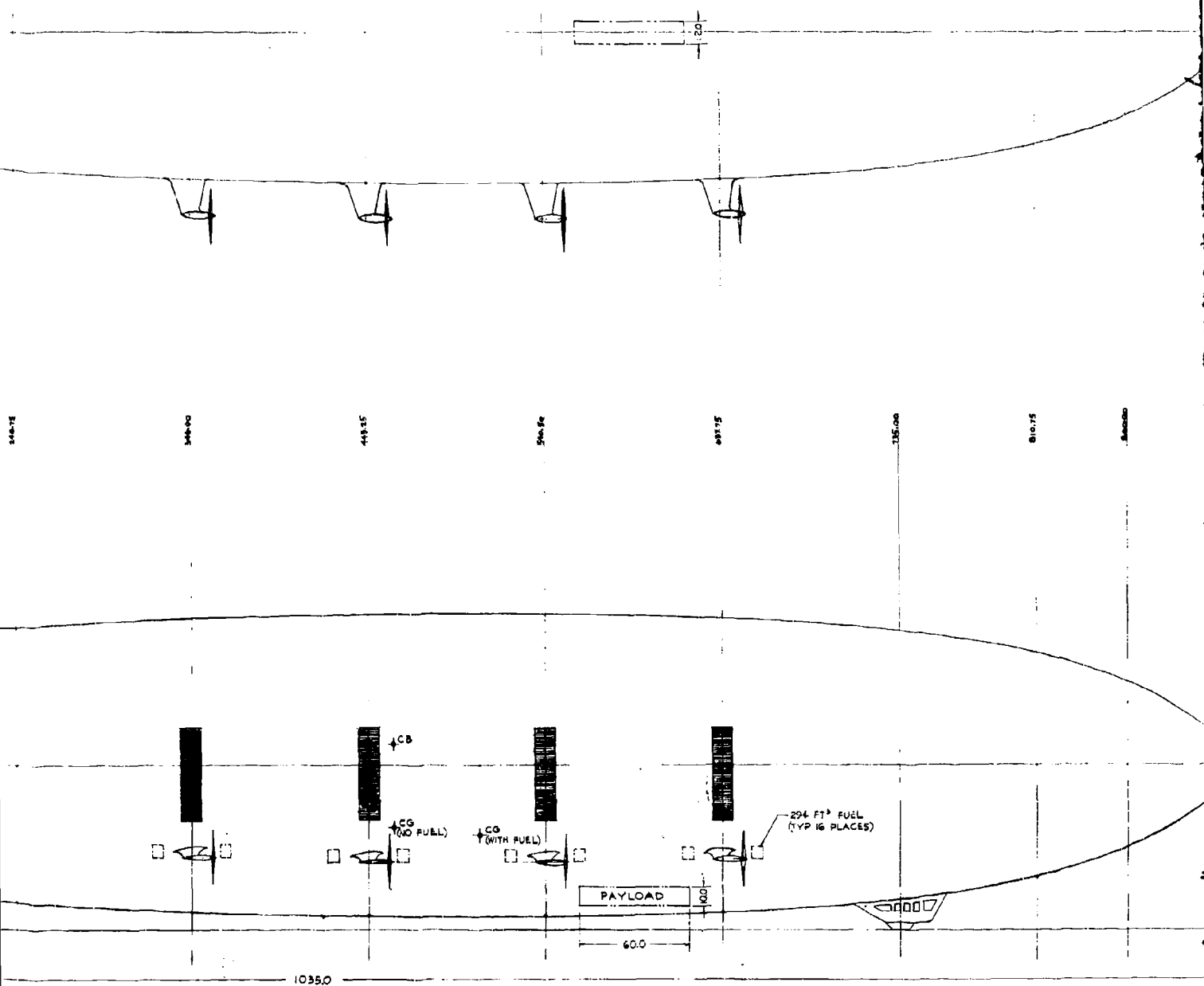


Figure 5 - Conventi

B

GOODYEAR AEROSPACE
CORPORATION

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OVERALL HULL DIMENSIONS

HEIGHT	167.0 FT
WIDTH	167.0 FT
LENGTH	1035.0 FT

GENERAL DATA

FINENESS RATIO OF HULL	6.2
HULL VOLUME	17000,000 CU FT
GAS VOLUME @ 10,000 FT ALT	15900,000 CU FT
GAS VOLUME @ SEA LEVEL	11,750,000 CU FT
GROSS LIFT @ $\frac{1}{2}W = 0.9$	825,000 LBS
EMPTY WEIGHT	495,000 LBS
USEFUL LOAD	350,000 LBS
FUEL	245,000 LBS
PAYLOAD	105,000 LBS

POWER PLANT

ENGINE POWER (8 x 3,125 HP)	25,000 HP
PROPELLER DIA	30 FT

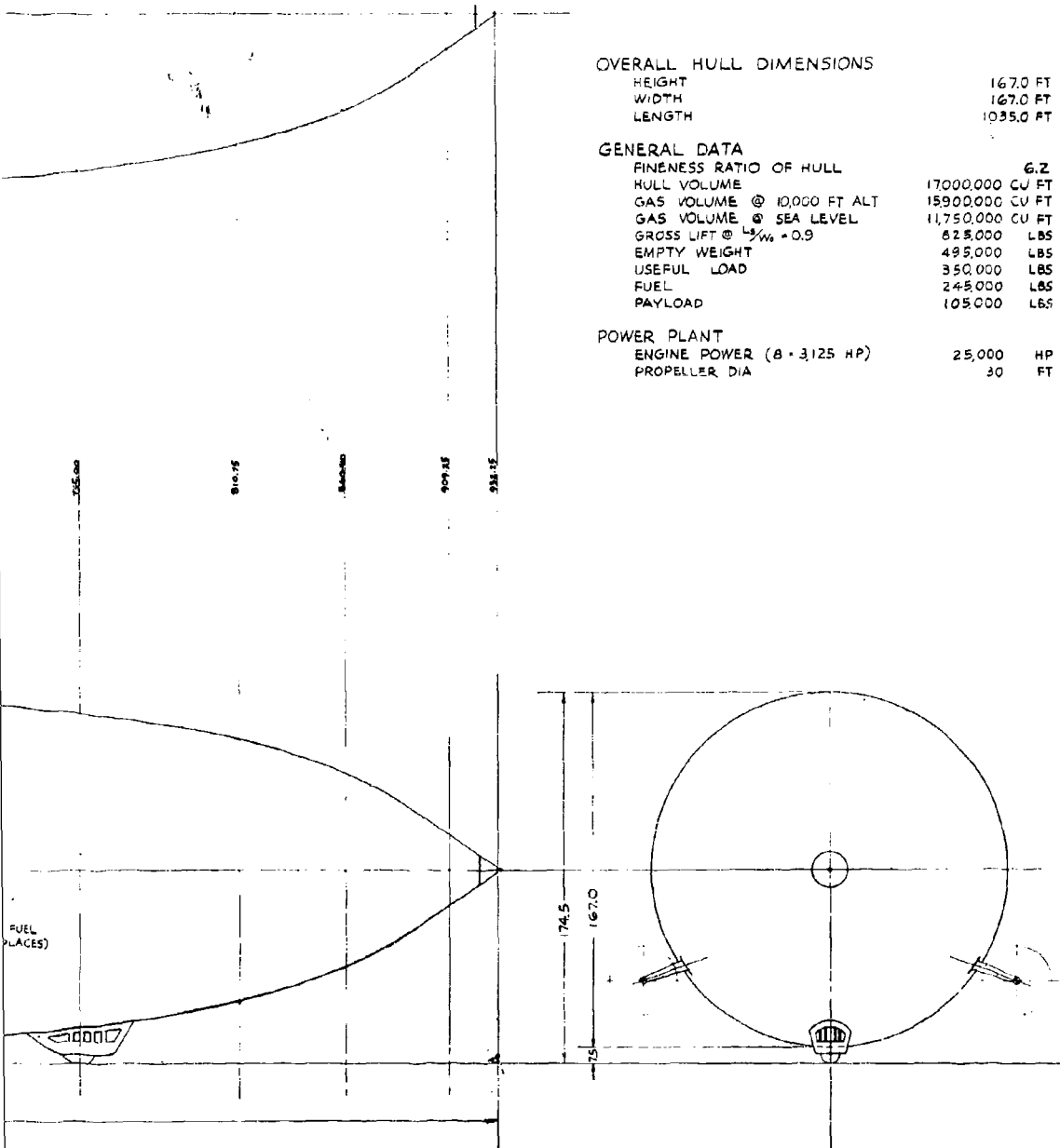
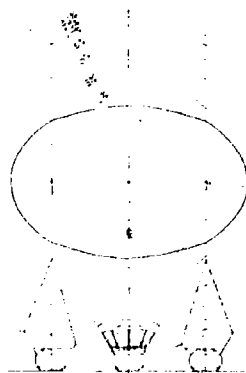
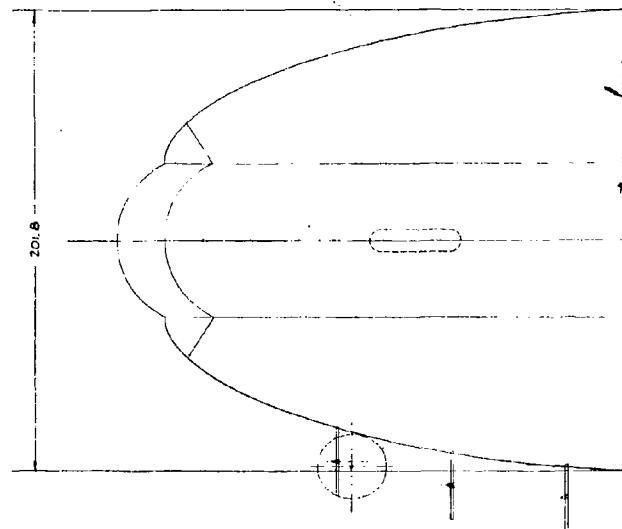


Figure 5 - Conventional Rigid Airship

GOODYEAR AEROSPACE	
CONSTRUCTION	
RIGID AIRSHIP	
CARGO CARRIER	
17,000,000 CU FT	
67QSI643	

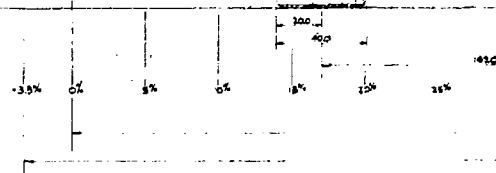
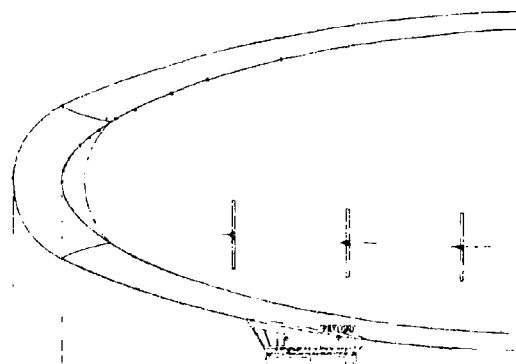
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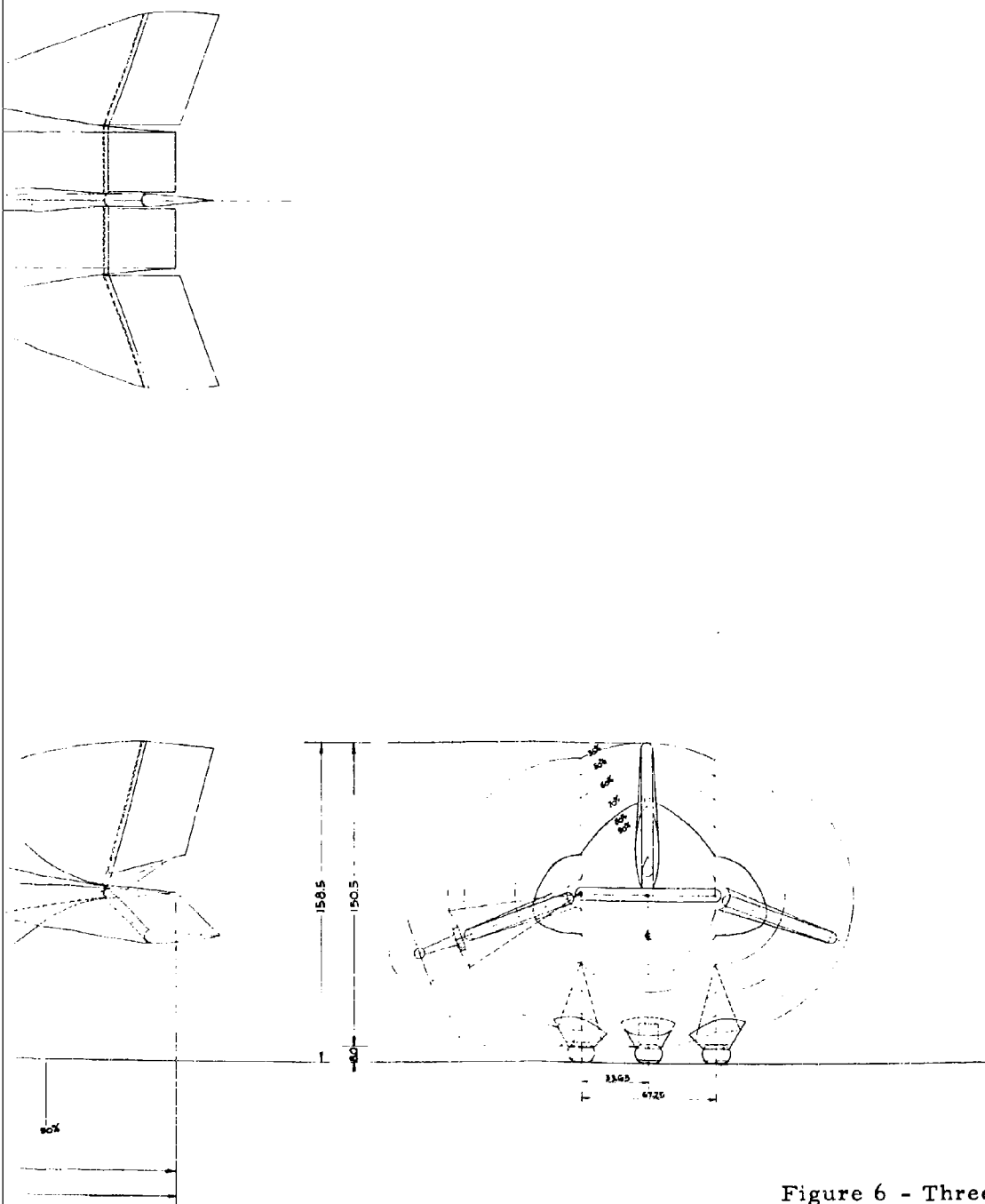
PLANE OF PROPS
(VITOL POSITION)

4 STRUT ROTATION

-- FUEL TANK (REP) TYPE



A



OVERALL HULL DIMENSIONS
 HEIGHT
 WIDTH
 LENGTH
 LENGTH (ENVELOPE ONLY)

GENERAL DATA
 FINENESS RATIO OF HULL ($\frac{\text{HULL LENGTH}}{\text{MAX DIA}}$)
 HULL VOLUME
 GAS VOLUME
 BALLONET VOLUME
 STATIC LIFT @ 10,000 FT ALT
 DYNAMIC LIFT
 GROSS LIFT @ $\frac{L}{W} = 0.6$
 EMPTY WEIGHT
 USEFUL LOAD
 FUEL
 PAYLOAD

POWER PLANT
 ENGINE POWER (16 * 2,000 HP)
 PROPELLER DIA

Figure 6 - Three-Lobe DYNASTAT

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CORPORATION

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OVERALL HULL DIMENSIONS

HEIGHT	130.5 FT
WIDTH	201.8 FT
LENGTH	661.4 FT
LENGTH (ENVELOPE ONLY)	589.4 FT

GENERAL DATA

FINENESS RATIO OF HULL ($\frac{\text{HULL LENGTH}}{\text{MAX DIA}}$)	3.79
HULL VOLUME	8,512,000 CU FT
GAS VOLUME	2,230,000 CU FT
BALLONET VOLUME	399,000 LBS
STATIC LIFT @ 10,000 FT ALT	246,000 LBS
DYNAMIC LIFT	645,000 LBS
GROSS LIFT @ $\frac{L^3}{W_0} = 0.6$	550,000 LBS
EMPTY WEIGHT	315,000 LBS
USEFUL LOAD	220,500 LBS
FUEL	94,500 LBS
PAYLOAD	

POWER PLANT

ENGINE POWER (16 x 2,000 HP)	32,000 HP
PROPELLER DIA	30 FT

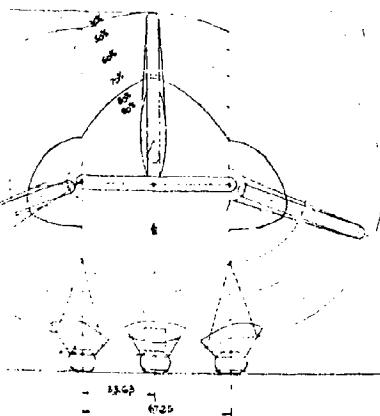
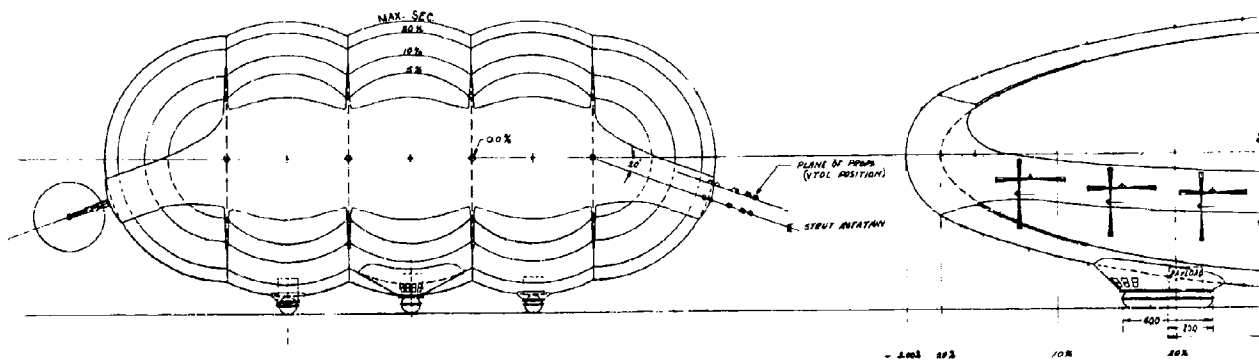
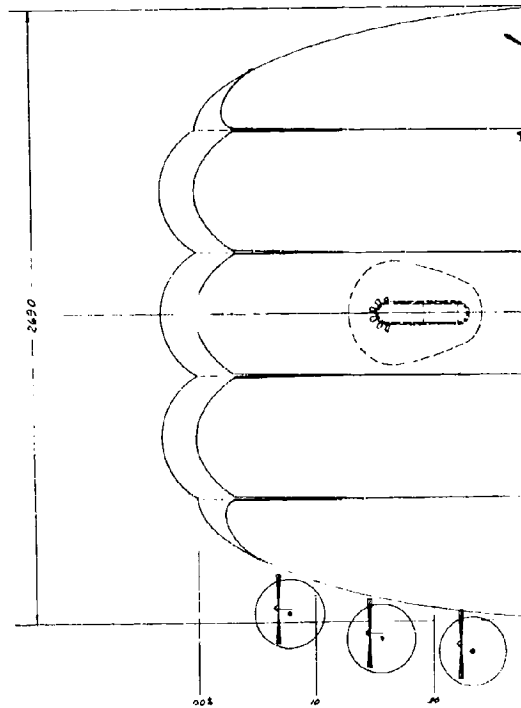


Figure 6 - Three-Lobe DYNASTAT

GOODYEAR AEROSPACE CORPORATION	
DYNASTAT	
3 LOBE	
8,550,000 CU FT	
67QSI644	

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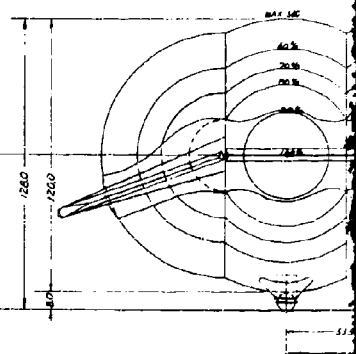
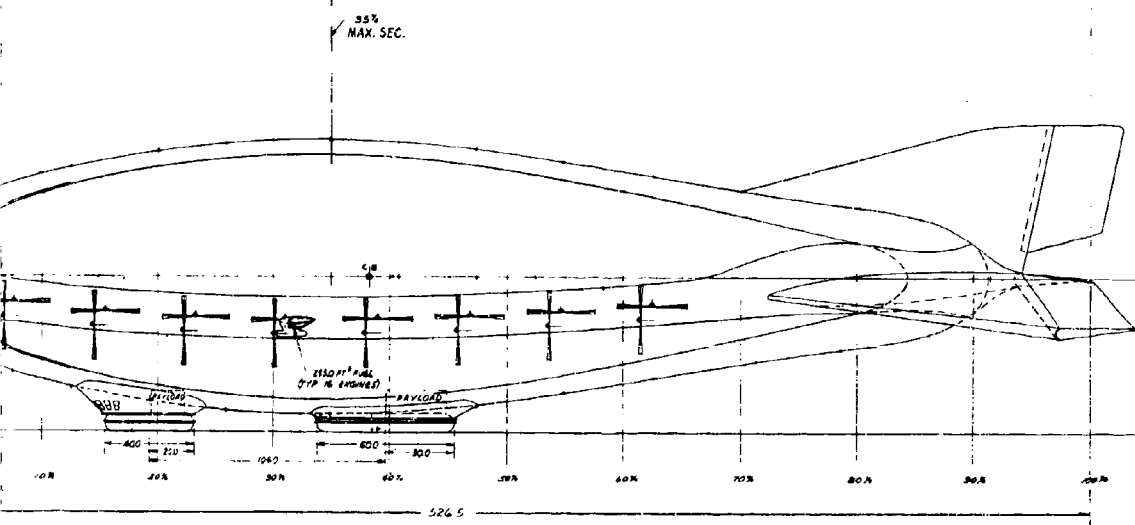
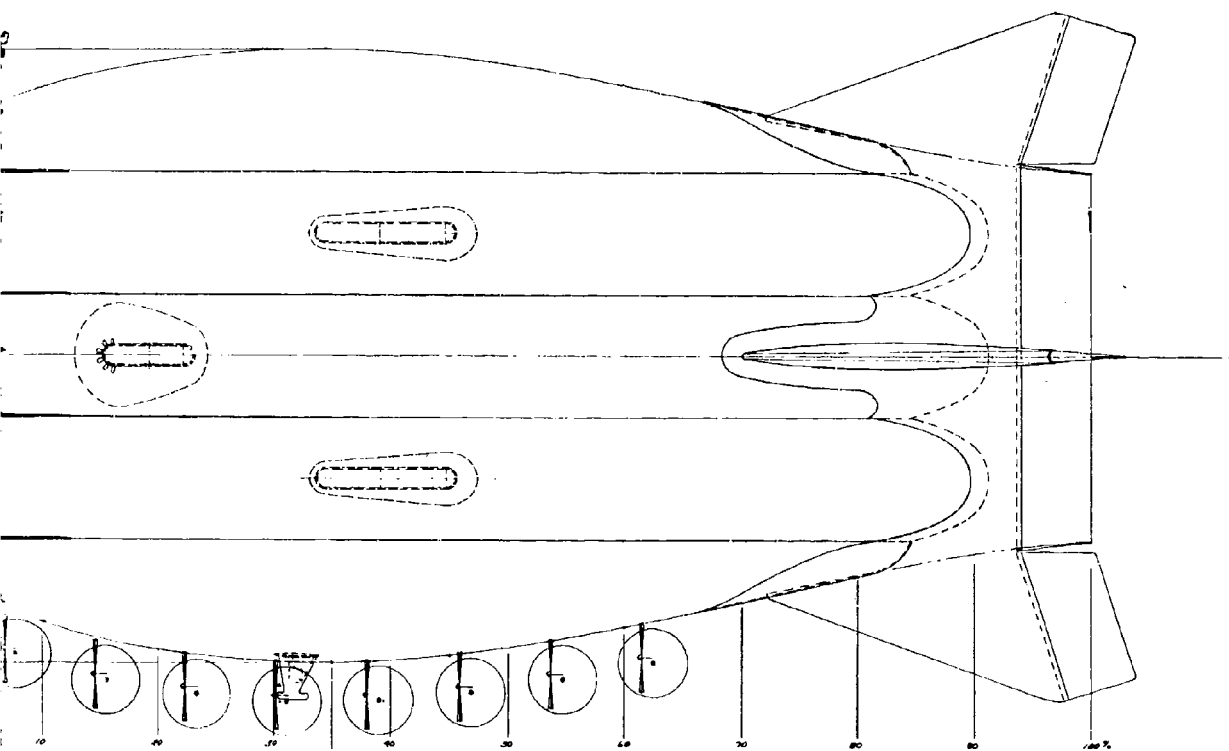


Figure 7 - P

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CORPORATION

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OVERALL HULL DIMENSIONS

HEIGHT	120.0 FT
WIDTH	269.0 FT
LENGTH	526.5 FT
LENGTH (ENVELOPE ONLY)	482.0 FT

GENERAL DATA

FINENESS RATIO OF HULL $\left(\frac{\text{HULL LENGTH}}{\text{EQUIV MAX SEC DIA}} \right)$	2.72
HULL VOLUME	
GAS VOLUME	8,550,000 CU FT
BALLONET VOLUME	2,230,000 CU FT
STATIC LIFT @ 10,000 FT ALT	399,000 LBS
DYNAMIC LIFT	246,000 LBS
GROSS LIFT @ $\frac{1}{2} W_0 = 0.6$	665,000 LBS
EMPTY WEIGHT	386,000 LBS
USEFUL LOAD	279,000 LBS
FUEL	95,000 LBS
PAYLOAD	84,000 LBS

POWER PLANT

ENGINE POWER (16 x 2250 HP)	36,000 HP
PROPELLER DIA	30 FT

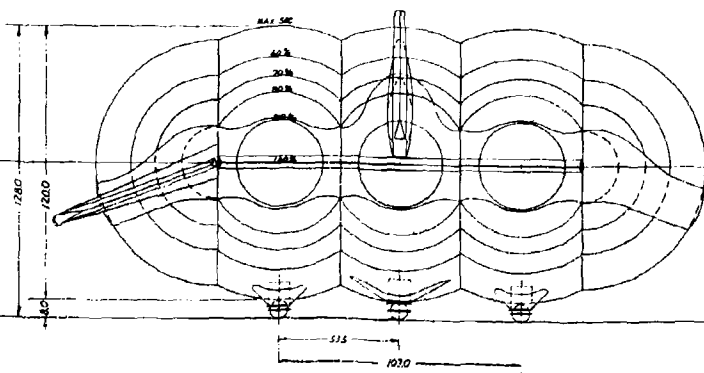
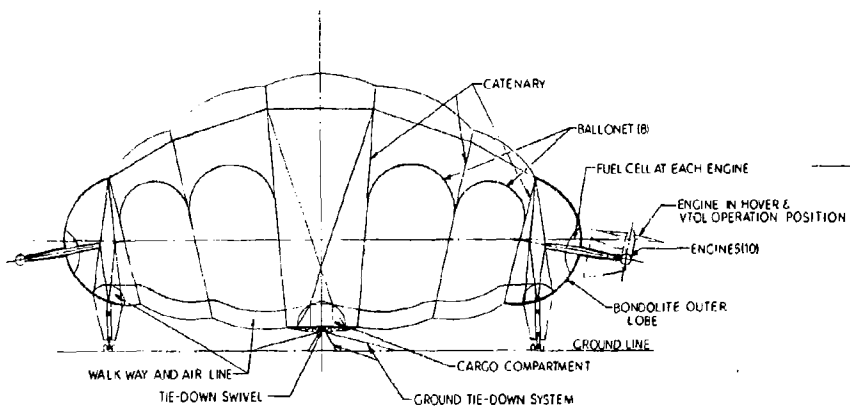


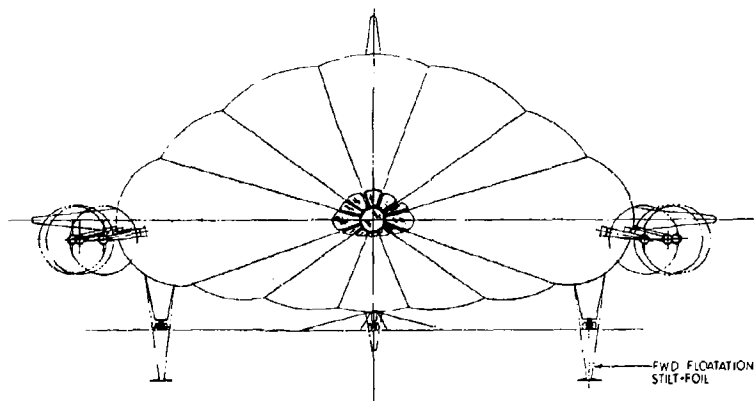
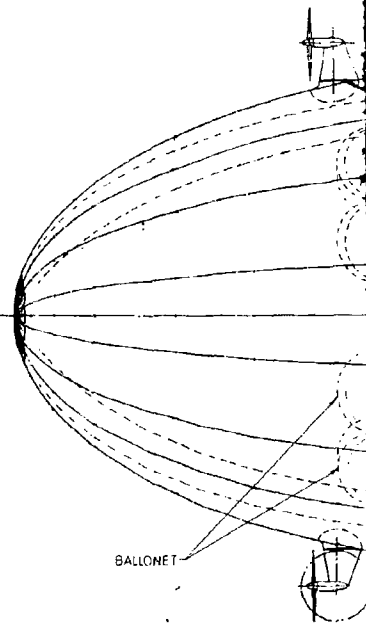
Figure 7 - Five-Lobe DYNASTAT

GOODYEAR AEROSPACE CORPORATION	
DYNASTAT 5 LOBE	
8,550,000 CU FT	
DATE	67QS977
DESIGNED BY	25300
CHECKED BY	12340
APPROVED BY	12340

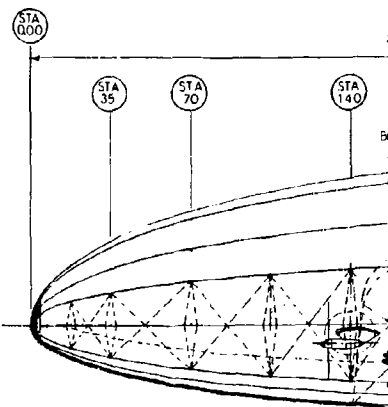
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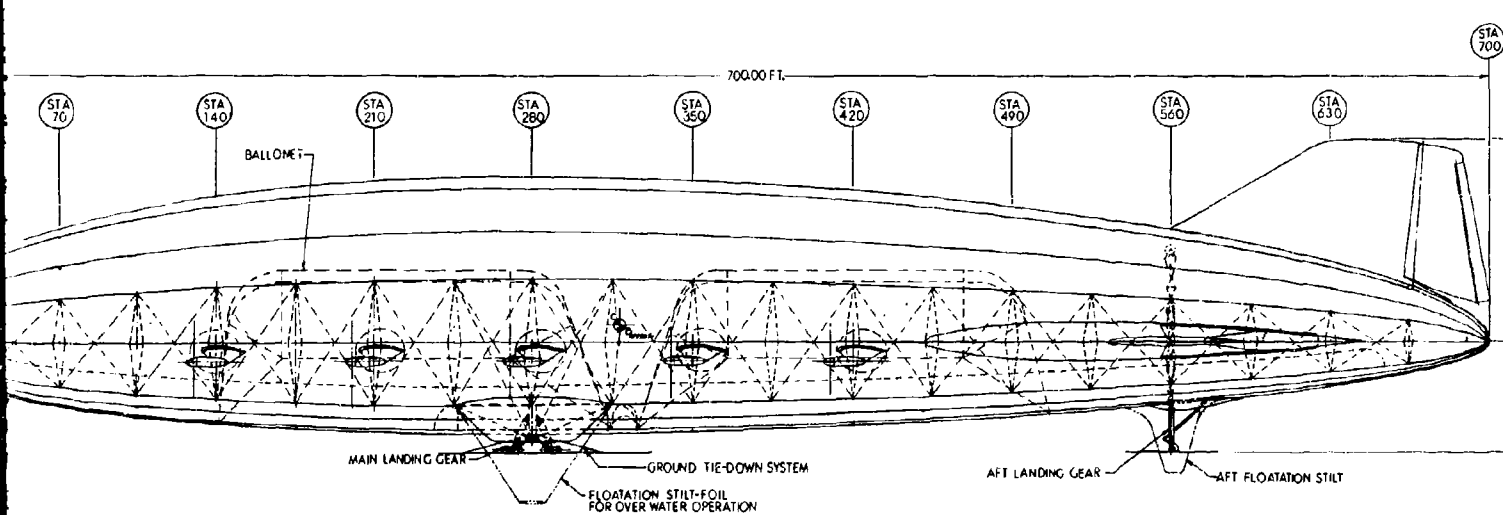
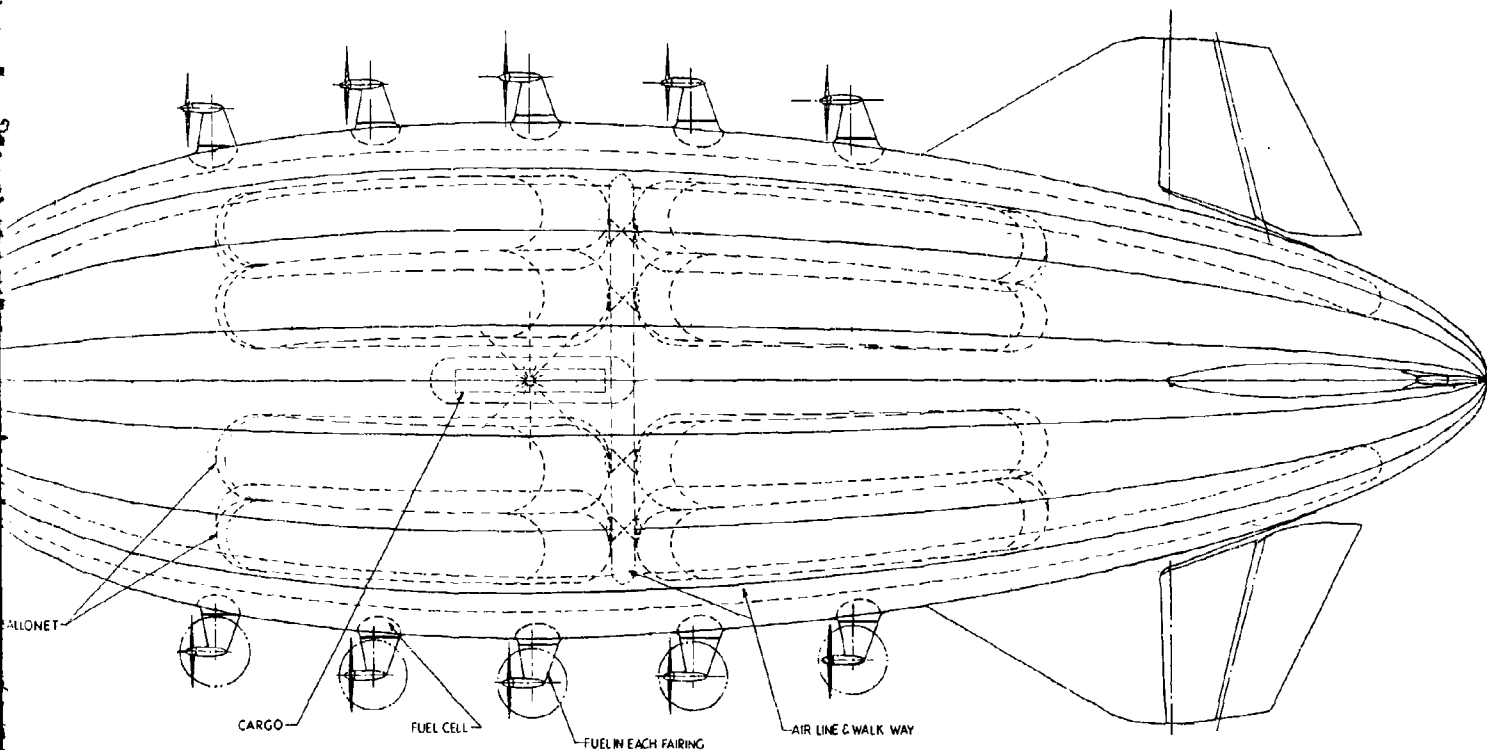


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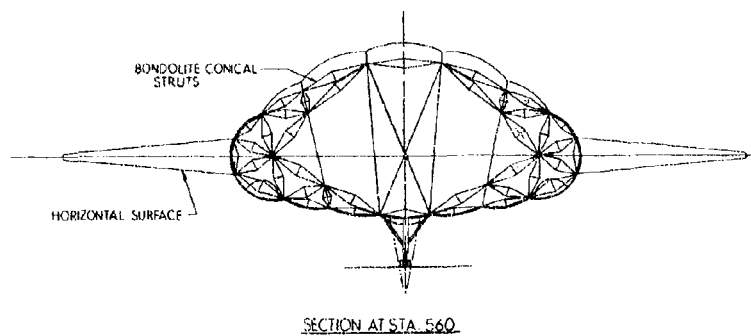
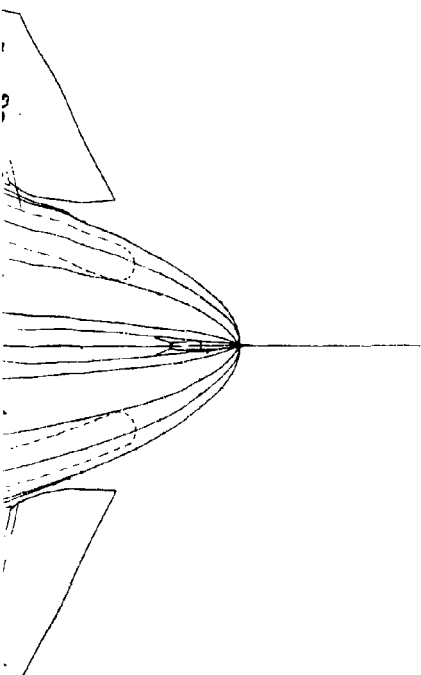


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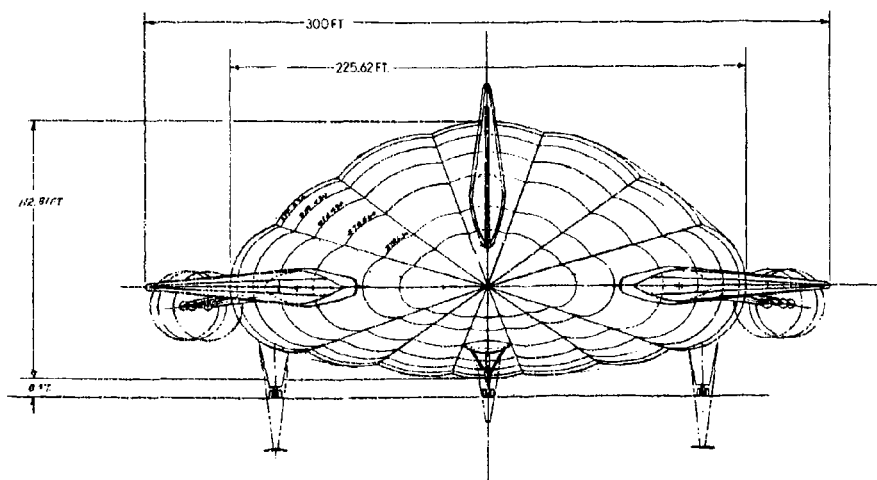
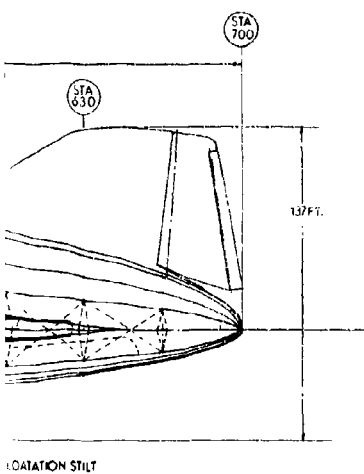
B



OVERALL DIMEN
HEIGHT
WIDTH
LENGTH(OVE

GENERAL DATA
FINENESS RA
GAS VOLUM
BALLONET
STATIC LIFT
DYNAMIC U
GROSS LIFT
EMPTY WEIG
USEFUL LO
FUEL
PAYLOAD

POWER PLANT
ENGINE PC
PROPELLER

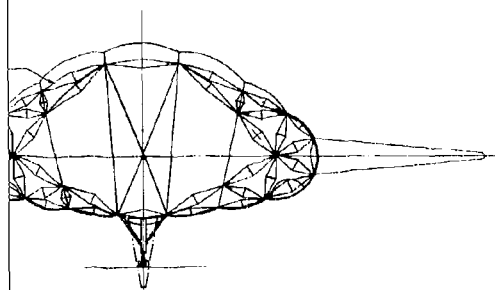


C

Figure 8 - "Idealized" DYNASTAT

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CORPORATION

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SECTION AT STA. 560

OVERALL DIMENSIONS

HEIGHT	137 FT.
WIDTH	300 FT.
LENGTH(OVERALL)	700 FT.

GENERAL DATA

FINENESS RATIO OF HULL ($\frac{\text{HULL LENGTH}}{\text{EQUIV. MAX. SEC. DIA.}}$)	45
GAS VOLUME	8,550,000 CU. FT.
BALLONET VOLUME	2,230,000 CU. FT.
STATIC LIFT 10,000 FT.	399,000 LBS.
DYNAMIC LIFT	266,000 LBS.
GROSS LIFT @ $L/W_0 = 0.6$	665,000 LBS.
EMPTY WEIGHT	340,000 LBS.
USEFUL LOAD	325,000 LBS.
FUEL	227,500 LBS.
PAYLOAD	97,500 LBS.

POWER PLANT

ENGINE POWER (10x2900HP)	29,000 HP
PROPELLER DIA.	30 FT.

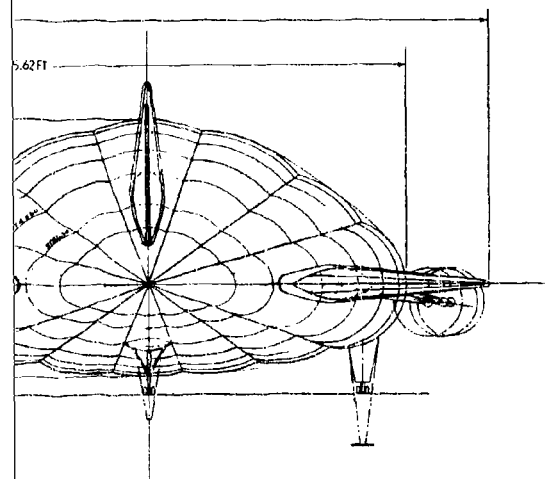


Figure 8 - "Idealized" DYNASTAT

GOODYEAR AEROSPACE	
DYNASTAT	
8,550,000 CU. FT.	
DATE	67QS/645
REV.	25000
DESIGNED BY	12/24/72
CHECKED BY	12/24/72

SECTION III - PARAMETRIC PERFORMANCE STUDY BOUNDARIES

The parametric performance study is bounded as follows, either by contract requirements, reference (1), or as developments in the study indicated:

Four gross weights, *	$W_o =$	100,000 lbs. 250,000 lbs. 625,000 lbs. 1,500,000 lbs.
Three maximum design speeds, $V_{max_{nrp}}$	$=$	70 knots 140 knots 210 knots
Static lift/gross weight ratio L_s/W_o	$=$	1.0 0.8 0.6 1.0 0.9 0.8
		} DYNASTAT } Conventional } airship
Configurations:		Conventional rigid Conventional non-rigid 3-lobe DYNASTAT } semi-rigid type 5-lobe DYNASTAT }

The following fixed weights are part of the dry structural weights of all ships:

Avionics	8,000 lbs.
Electrical generation equipment	2,500 lbs.
Crew (10) = 10(170 + 30lb)	2,000 lbs.

Final payload capability, W_{f+pl} , is gross weight, W_o , minus dry structural weight, including engines, propellers, and auxiliary equipment and with a fuel tankage weight of 0.46 lbs./gal. or 0.077 lbs./lbs. of fuel. The tankage weight

* W_o is, as used throughout the report, the total loaded gross weight of a given ship exclusive of the weight of the lifting gas. In some aerodynamic and structural problems of dynamic response, the mass of the lifting gas and of the displaced air mass must be considered.

for a 30 percent payload-70 percent fuel situation was made a part of the dry weights and not varied further, as not warranted. A food and water allowance for the 10-man crew of 224 lbs./day was ignored as insignificant.

It was decided early in the program to look at each gross weight at three altitudes, although this increased the sheer volume of data necessary. However, if this were not done, an unnecessary penalty would be imposed on the performance of a ship having only a low-altitude requirement, if sized for a high altitude. Envelope volume is a function of gross weight, design altitude and L_s/W_o ratio (Figure 3). The low level designed ship is, of course, smaller with better aerodynamic performance and lower structural weights.

Design altitudes selected are: $h_3 = 20,000$ ft.
10,000 ft.
5,000 ft.

Intermediate altitudes from h_3 are:

h_3	h_2	h_1
20,000 ft.	10,000 ft.	1,500 ft.
10,000 ft.	5,000 ft.	1,500 ft.
5,000 ft.	3,000 ft.	1,500 ft.

Four propulsion types were studied: Turbo-prop
Reciprocating-compound
Diesel
Rotating-combustion
chamber (Wankel)

It was quickly apparent that the turbo-prop poses ballasting problems in an application to a neutrally-buoyant airship. The coupling of water recovery apparatus to the exhaust of such an engine does not appear feasible. The turbine ingests and exhausts air in quantities several times that of a reciprocating engine of similar power. Temperature of exhaust is also much higher. Exhaust heat-exchanger equipment would necessarily be larger and more rugged. There also would ensue a serious effect on turbine performance from the resultant exhaust back-pressure. The engine could be applied to a ship flying "heavy" throughout its mission and thus not needing ballasting. In Section IX other applications of the turbo-prop are discussed. The regenerative turbine is an engine of promise in the future.

The "Wankel" engine, a Curtiss-Wright development in this country, shows promise of approaching the weights of a turbo-prop with the fuel economy of the reciprocating engine. Addition of supercharger weight for altitude capability brought its weight close to the reciprocating engine. While this engine may have future promise, particularly at low altitudes without supercharging, its capabilities at the present time do not indicate a superiority over the reciprocating engine.

The two power plants upon which the computer-calculated performance tables are based are the reciprocating-compound direct injection engine (modelled on the 981TC18EA-1, R 3350-34 Wright) and an air-cooled Diesel tank engine by Continental [References (16) and (18)]. "Rubber" engines were assumed; whatever odd horsepower per engine was necessary was assumed available. Minimum number of engine-nacelles was two. Where power requirements were high number of engines was $BHP_{total}/5,000 = N_E$.

Power requirement is calculated for design altitude. As dry structural weights are affected by volume, design speed, and design altitude ships are necessarily "q"-limited. True maximum speed at lower altitude must be held to the "q" of design "altitude-velocity".

An on-board electrical power requirement of 200 BHP is assumed for the 8,000 lbs. of avionics plus necessary "housekeeping" requirements (Reference 27). This figure includes appropriate efficiency factors for AC and DC power generation.

In addition to V_{max} which determined necessary power plant weights, $V_{min bhp}$ (speed for greatest endurance) and $V_{max range}$ (speed at which V/BHP_{req} is minimum) were computer determined. For the latter two speeds, 200 HP in addition to the thrust HP is used. For V_{max} , no on-board HP is being used. A minimum sustained speed for controllability of 30 knots was established. Nearly all buoyant ships ($L_s/W_o = 1.0$) have maximum endurance and maximum range at this minimum speed. Some of the 70-knot designed "heavy" ships cannot achieve the theoretically-required speeds for best endurance or range, although their payload capability may actually enable them to out-range their sister ships carrying more total power for a greater design V_{max} .

It must be realized that an airship is capable of sustaining greater or lesser loads than design payloads. A 10,000 foot pressure-height designed airship can carry greater weights at lower altitudes by the simple expedient of adding helium - which by definition reduces its pressure height. Winter operation, because of greater air density due to lower temperatures, permits addition of helium. There are structural ramifications to any of these considerations. The theoretical lifting capability under some off-design condition may not safely be usable if the necessary strength is not built in at the right places.

All airships of this study are sized for gross weight and a specific design altitude, h_3 , under standard atmospheric conditions, Reference (19). The airship can carry its gross weight from sea-level to design altitude and back to sea-level, provided no helium is lost (see Appendix B). A real airship will have varying gross weights, as explained above, affected by seasonal, geographic, or operational considerations, these usually being a matter of detailed design specifications.

General assumptions for parametric performance study:

1. Conventional rigids are assumed designed to the "Hindenburg" or "Akron" type of ring-frame and transverse girder structure.
2. Conventional non-rigids are assumed designed to the most recent "blimp" construction of the U. S. Navy; pressure-rigidized helium-filled envelope of coated fabric with metal-structure fins and car.
3. DYNASTATS are of non-rigid or semi-rigid design.
4. Propulsion is conventional (see design assumption No. 3) and chemically-fueled only.
5. In computer performance problems only sufficient number of total installed engines are being run at nearest possible optimum power settings for condition under study. Inactive propellers are feathered.
6. Ballasting is assumed by means of appropriate engine exhaust water recovery apparatus. Neutral buoyancy, when reached, is assumed maintained.

7. All performance is based on the U.S. standard atmosphere (Reference 19). (See Appendix B for aerostatic effect of off-standard conditions).
8. No physical constraints were imposed to fit presently existing manufacturing or hangar facilities.

Design assumptions involved in weight and performance tables:

1. Non-rigid airships are designed with a fineness ratio of 4.70; rigids are designed with a fineness ratio of 5.5. These figures reflect current approaches to optimization from a weight versus drag standpoint and would undoubtedly vary with each mission.
2. "Rubber" engine and reduction gearing has been used permitting optimum utilization of power.
3. Engines may be mounted internally or externally to the airship car in nacelles at the extremes of cantilevered outriggers. This is considered best design for long range where decreased drag compensates for an increase in weight over the truss type outrigger. An admitted penalty is incurred for short-duration missions, but the loss is not excessive.
4. Suspension systems for non-rigids have distributed loading of 65 percent internal and 35 percent external. This conforms to distribution on latest Goodyear production designs, although optimizing will produce variations from these figures for each volume and car-loading.
5. The three fin inverted Y empennage arrangement is used on all conventional non-rigid airships. This is considered at present as most efficient design.
6. A four cable/fin tail bracing is applied to all designs. This again favors the drag over weight considerations most suiting the long endurance mission. Faster ships probably should not have external bracing.

7. All control cables are completely faired or a 100 percent servo system is employed. Weight estimates are based upon the former.
8. All control cars are completely faired aft of the pilots' compartment.
9. All cars are designed to the same frontal area of 80 square feet.
10. External nose battens, faired as in current Goodyear Aerospace designs, are applied to all conventional non-rigid envelopes.

SECTION IV - PERFORMANCE

1. INTERPRETATION OF COMPUTER-GENERATED TABLES

The 105 tables following in this section are the computer-generated performance study within the boundaries defined in Section III. The weight, aerodynamic, aerostatic, and propulsion relationships from which these tables are computed are presented in Appendix A.

Each table is titled with the airship type, gross weight, W_o , design altitude, h_3 , and velocity, $V_{\max_{nrp}}$, engine type, and envelope volumes and resultant payloads, $W_f + pl$, for the three L_s/W_o ratios studied for each specific airship type. Neutrally-buoyant ships ($L_s/W_o = 1.0$) are assumed neutrally-buoyant throughout a flight by appropriate water-recovery ballasting. Thus, lines 1, 2, and 3 describe such a ship throughout any given mission.

"Heavy" ships ($L_s/W_o = 0.9, 0.8, \text{ or } 0.6$) are assumed to continue at neutral buoyancy if, during a mission, such a condition is reached.

Column 1 lists the appropriate L_s/W_o ratio of the ship under study, and represents its take-off condition. Column 2 indicates the ship's weight situation: W_o = gross weight; $W_1 = W_o - .25(W_f + pl)$; $W_2 = W_o - .50(W_f + pl)$; $W_3 = W_o - .75(W_f + pl)$. $W_f + pl$ is found in the upper right-hand corner opposite the appropriate L_s/W_o ratio and envelope total volume. Column 3 indicates design altitude and two lower altitudes. Column 4 lists design velocity or "q"-limited lower velocities at the lower altitudes. Column 5 lists the brake horsepower output required for the speeds of Column 4 and is thrust horsepower requirement only. Column 6 lists fuel flows for Column 5 horsepower and is calculated for the type of engine and power setting implied. Column 7 lists the speeds for minimum horsepower (which includes 200 HP for onboard power) and represents the speed for maximum time in the air. Column 8 lists the brake horsepowers appropriate to Column 7 speeds. Thrust horsepower for Column 7 speeds would be Column 8 powers minus 200 horsepower. Both Columns 7 and 10 speeds are affected by the absolute value

of the on-board power requirement. A change of this figure of 200 HP would change $V_{\min \text{ bhp}}$ and $V_{\max \text{ rge}}$ slightly.

Column 9 tabulates appropriate fuel flows for Column 8 horsepower. Column 10 lists the velocity for maximum range in still air. Column 11 lists the horsepower appropriate (which includes the 200 HP figure) and Column 12 tabulates appropriate fuel flows.

Whenever Column 7 or Column 10 speeds were impossible (i. e., beyond design V_{\max}) no further print-out occurred.

In most cases the ship structural weights included an allowance for water recovery apparatus. In some cases, normally only of "heavy" airships where neutral buoyancy was unlikely ever to be achieved, water recovery apparatus was eliminated. Where W_{f+pl} is based on a ship with no water recovery apparatus, the L_s/W_o designation in the upper right-hand corner is preceded by an asterisk.

Whenever the computer was dealing with powers well below the total installed power, it was directed to base fuel consumption on the number of engines necessary to be run at the nearest optimum B. S. F. C. for the engine type and altitude. This results in some discrepancy in fuel flow at identical speed and power settings, between 70-knot and 140-knot capable ships. The faster ships have far greater power, but may at a 30 or 40 knot speed be required to operate on 400 HP when the individual power plants are 5,000 HP each. Some comment on engines, types and sizes, depending upon mission will follow later in this section and in Section IX.

2. RESULTS AND CONCLUSIONS FROM TABLES

Figures 9, 10, 11, and 12 present the design power requirement (regardless of engine type) for the conventional rigid and non-rigid, the 3-lobe DYNASTAT, and an "idealized" DYNASTAT, (one with zero-lift drag coefficient reduced). The limiting gross weights are for ships with reciprocating engines (Figure 11 includes limit with turbo-prop). With diesels the limit would be slightly higher; with turbo-props, lower. The

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CONVENTIONAL RIBS

h_g = 5,500 FT.

*L₁ = 1.0
 N₁ = 0.9
 N₂ = 0.5*

70,000

50,000

30,000

20,000

CELLAR
 ELKITE
 HF

10,000

7,000

5,000

3,000

2,000

1,000

STRESS RELIEFING

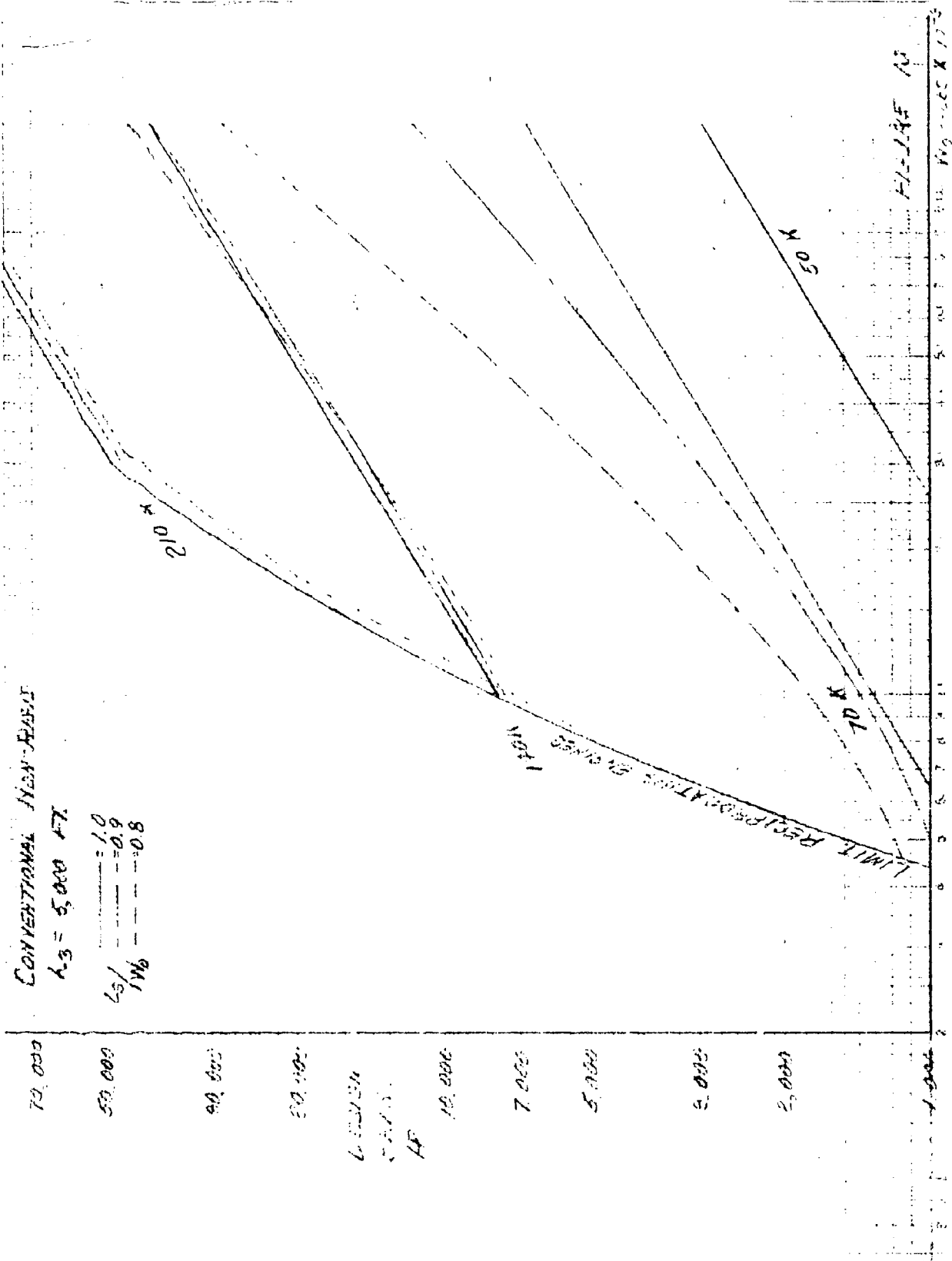
FIGURE 1

V₁₀ - 145 X 10⁻³

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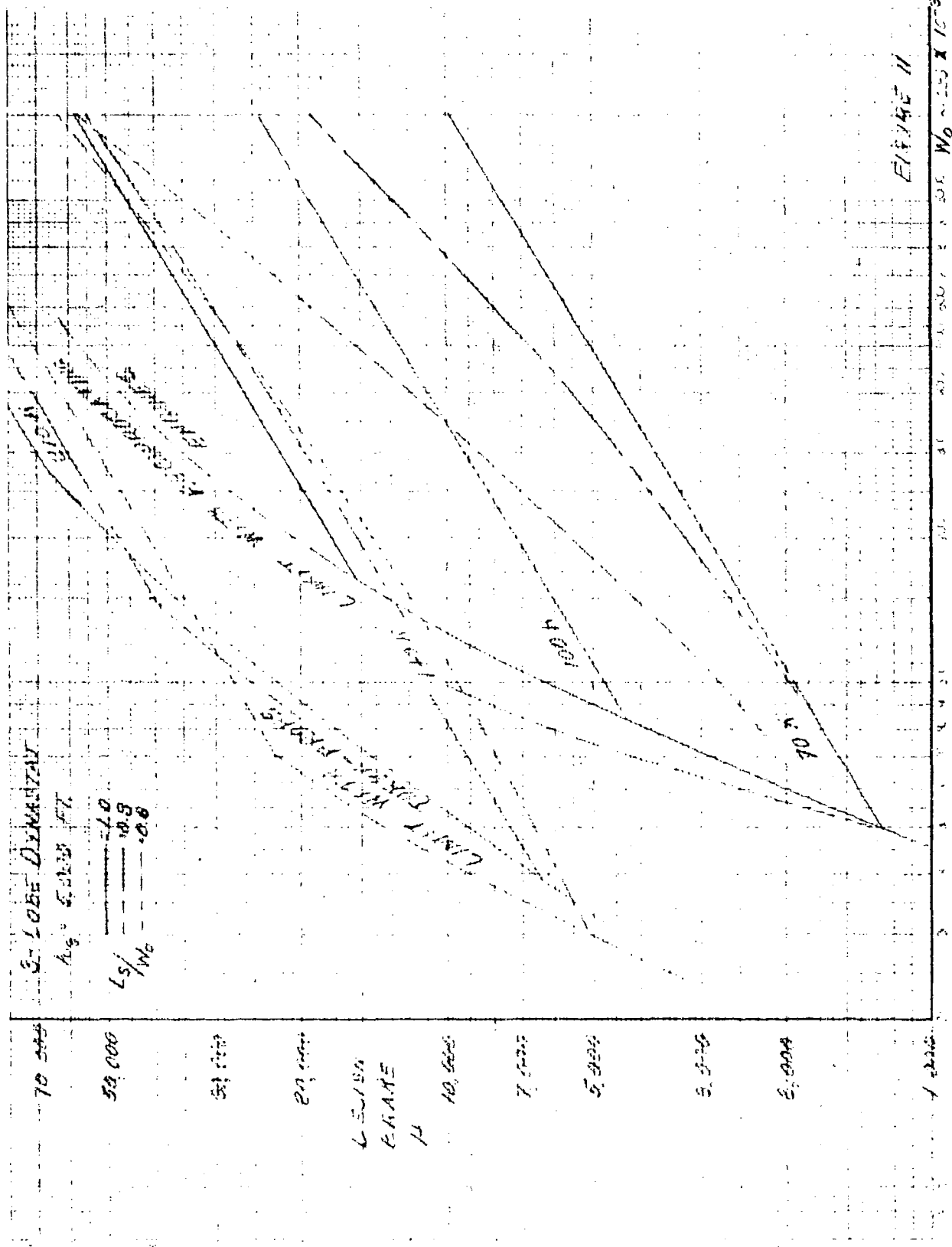


FIGURE 11

W6-25000-10-3

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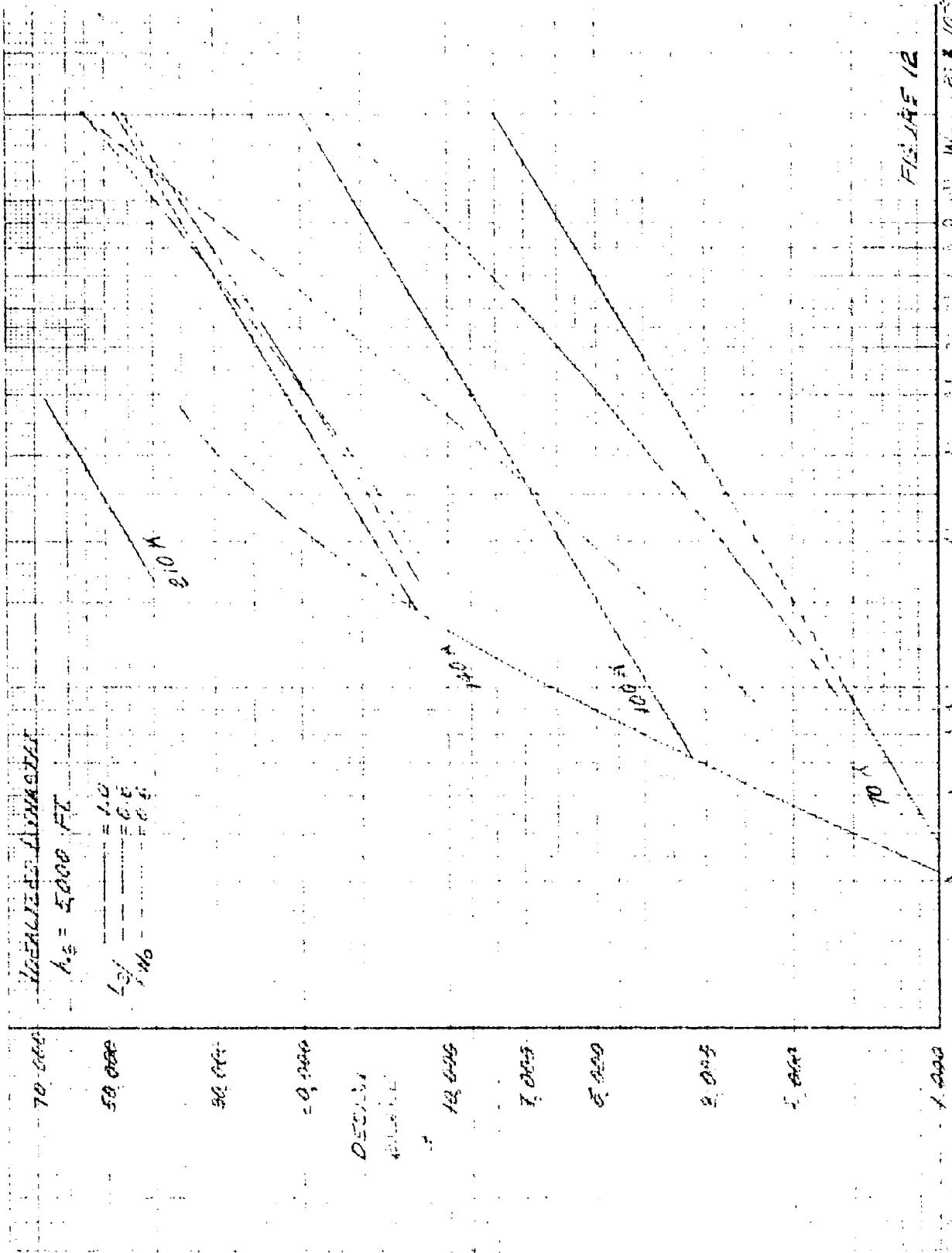


FIGURE 12

W0 10

conventional rigid and non-rigid were studied for both reciprocating engines and Diesels and results were always similar. The Diesel has better fuel economy at high power requirements (such as V_{\max}); at economy speeds the advantage is usually with the reciprocating engine. Comparison tables are shown for the conventional rigid with Diesel power in the 140-knot speed class. (Compare Tables IV-40, -48, with Tables IV-55, -63).

Figures 13, 14, 15, 16, 16A and 17 show variation of total payload, $W_f + p_l$, with gross weight, design speed, and L_s/W_o ratio. It is apparent that maximum payload and minimum power are obtained with a neutrally-buoyant ship at 70 knots. At 140 knots, payload is favored by "heavy" flight. Power requirement crosses over at higher sizes in this speed range, a "wing-loading" effect. At 210 knots, the advantages are all with "heavy" flight, to the maximum gross weights studied.

Figure 18 indicates the percentage loss of total payload due to the greater installed weight of diesel power over reciprocating engine power.

Figure 19 presents the total L/D ratios for conventional and DYNASTAT types, as a function of W_o and velocity.

Figures 20-23 are a plot of payload capability divided by V_{\max} power requirement. It should be remembered that this represents a "heavy" ship's initial condition; as it burns off its heaviness its power requirement will reduce.

On the basis of $W_f + p_l/BHP$ the non-rigid is superior to both the conventional rigid and DYNASTATS at 70 knots and at $L_s/W_o = 1.0$. Actually, the "heavier" conditions at 70 knots are not practical, certainly in the larger sizes and gross weights, because of extreme angles of attack.

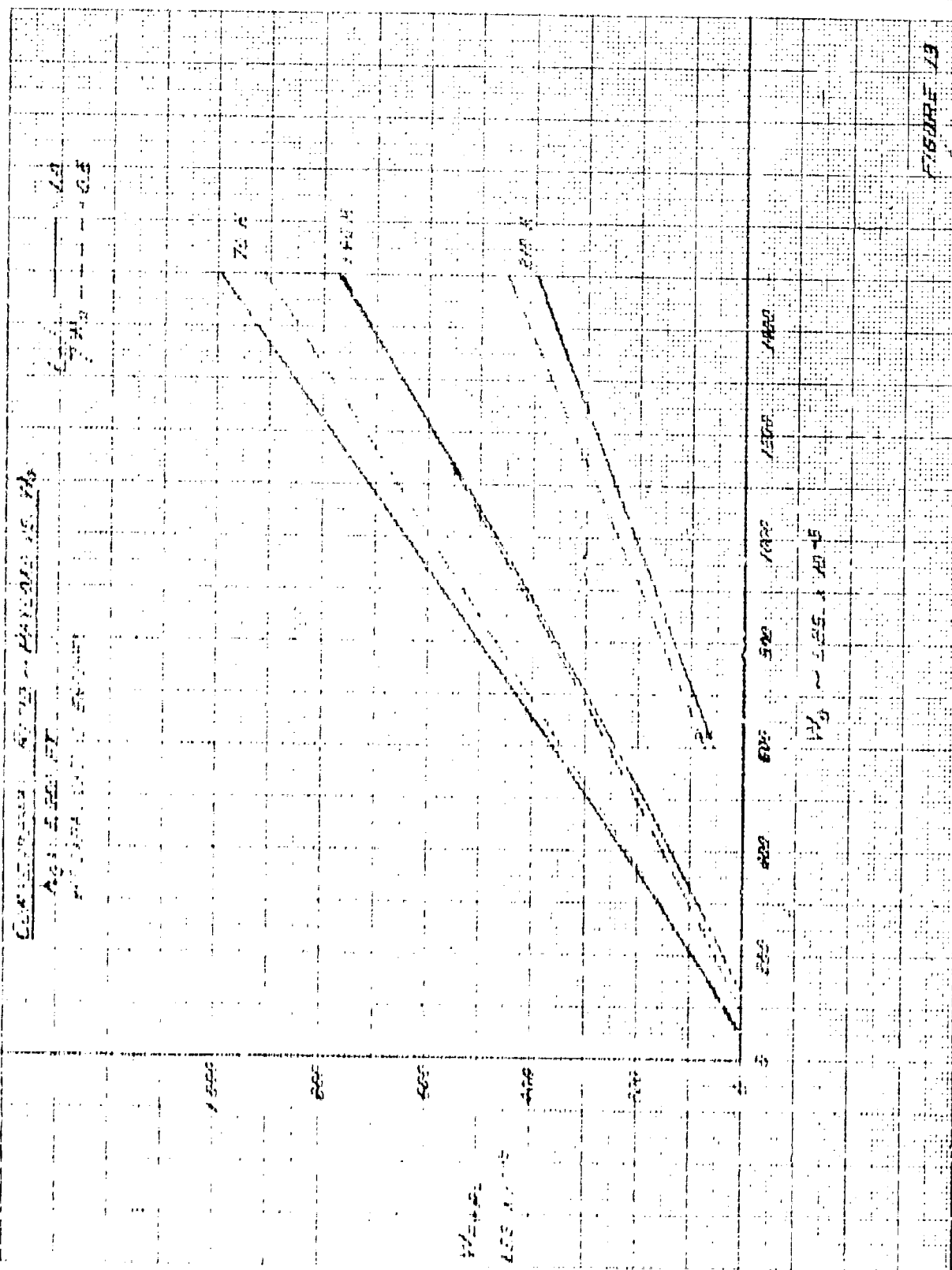
At 140 knots, the 100,000 pound ship has been eliminated in all types. In this speed range it is advantageous to fly "heavy" from the smallest to near the largest sizes studied. At 210 knots, the DYNASTAT is too heavy to fly with reciprocating engines and water recovery apparatus. With turbo-props it is very promising at both 210 and 140 knots (Figures 16A and 22A). At 140 knots, even with reciprocating engines, the DYNASTAT is competitive with the conventional rigid and non-rigid. (Figures 20, 21, 22, and 23). Since these are take-off comparisons, the advantages increase as heaviness is burned off. At 210 knots the

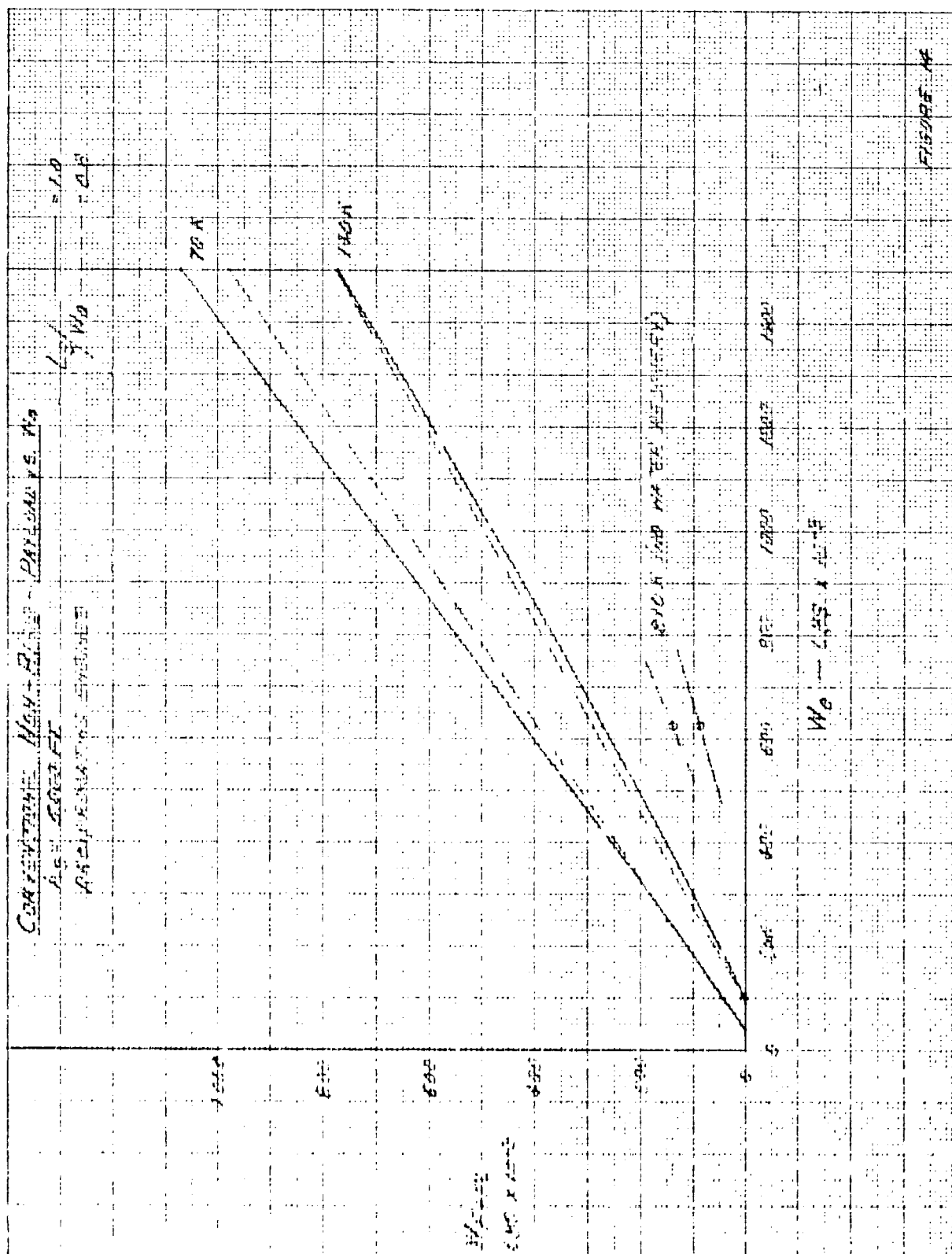
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FIGURE 13



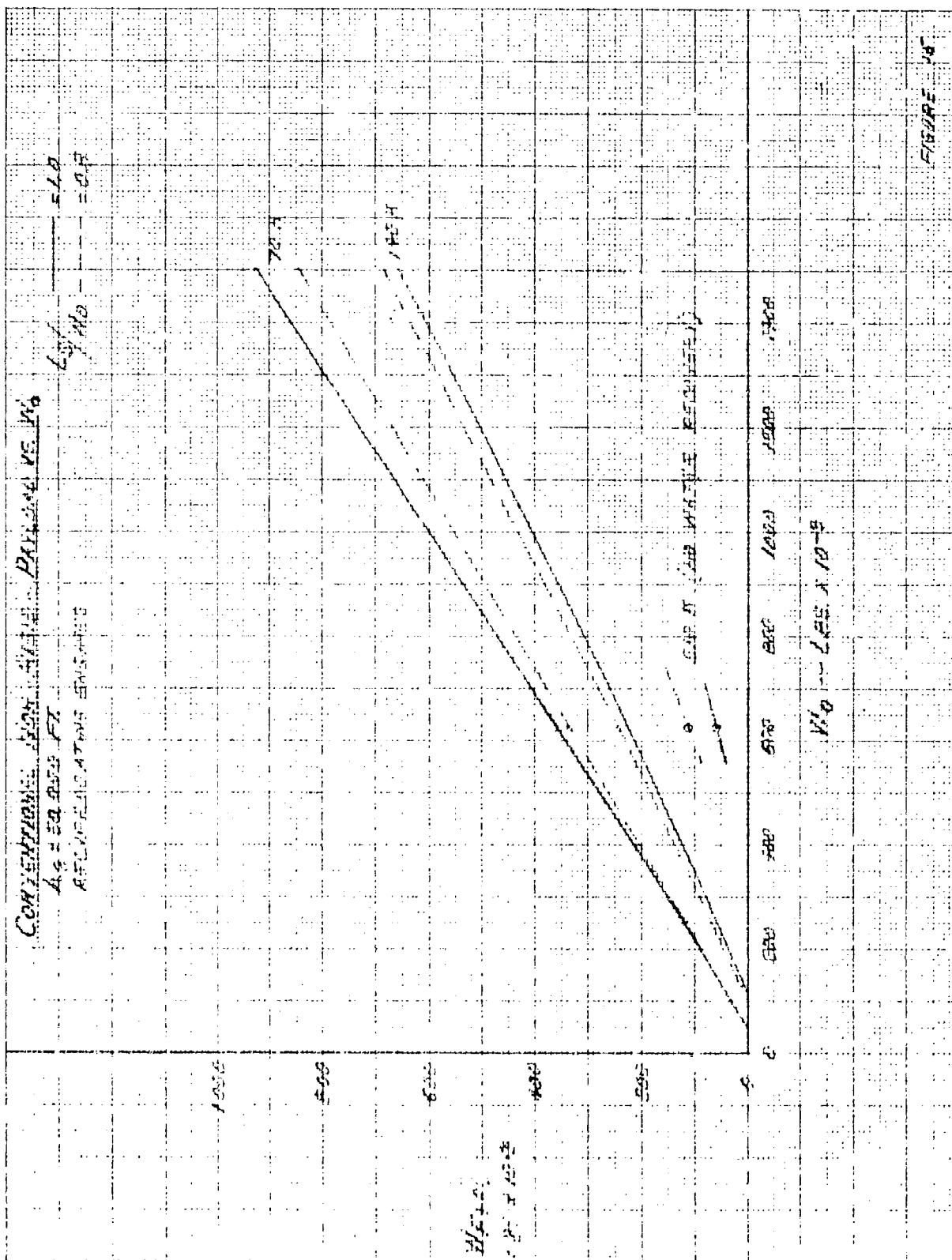


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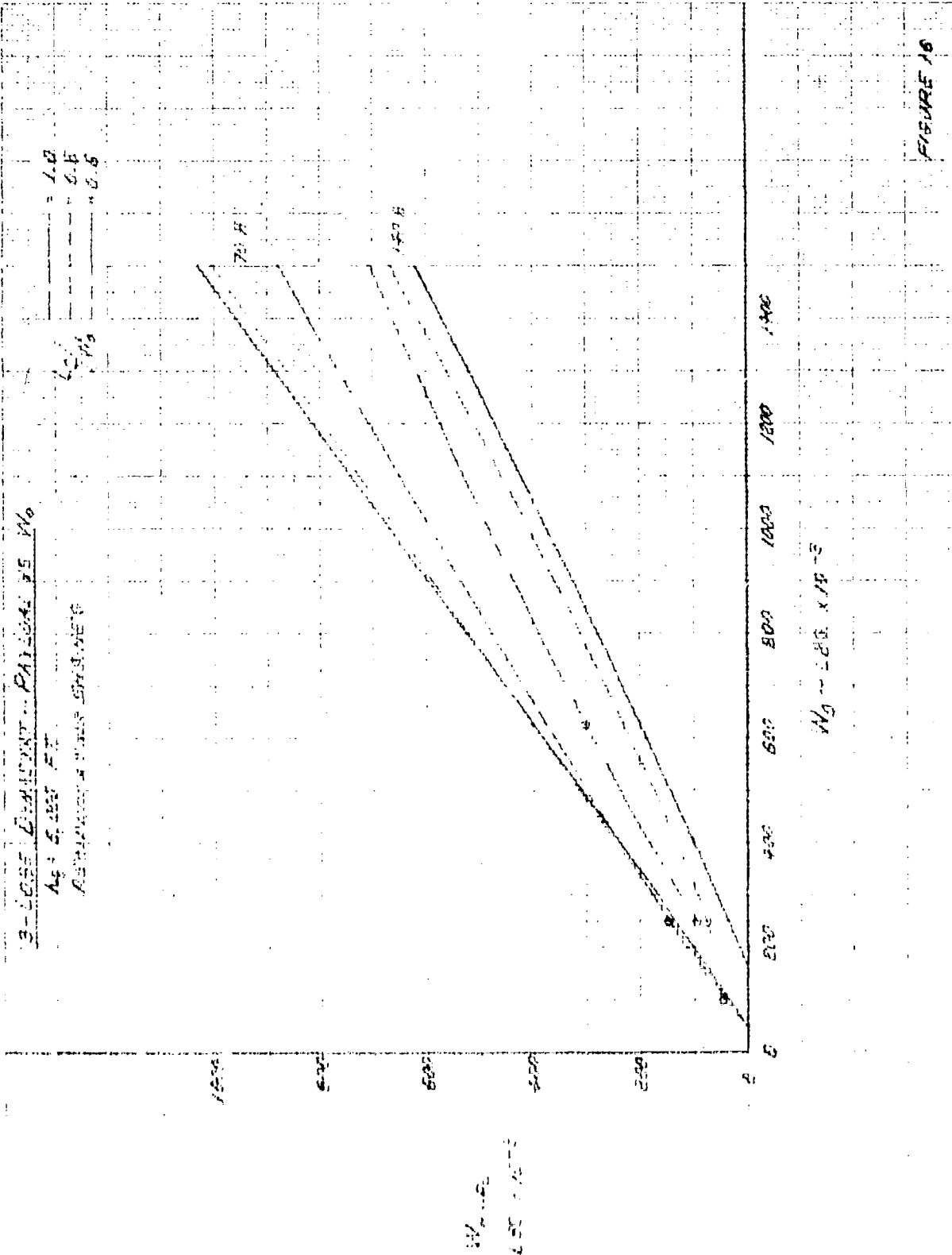


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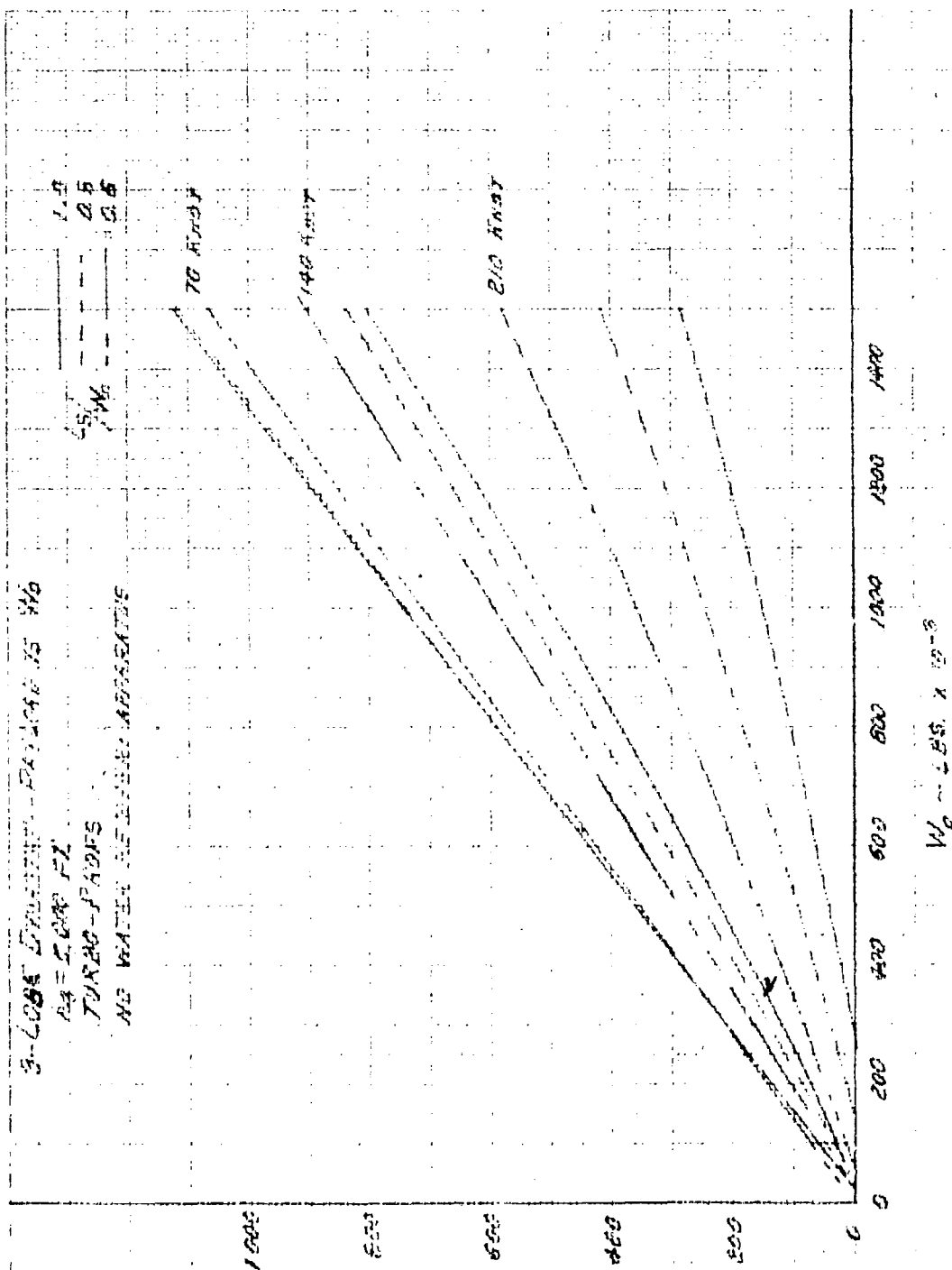
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FIGURE 15A



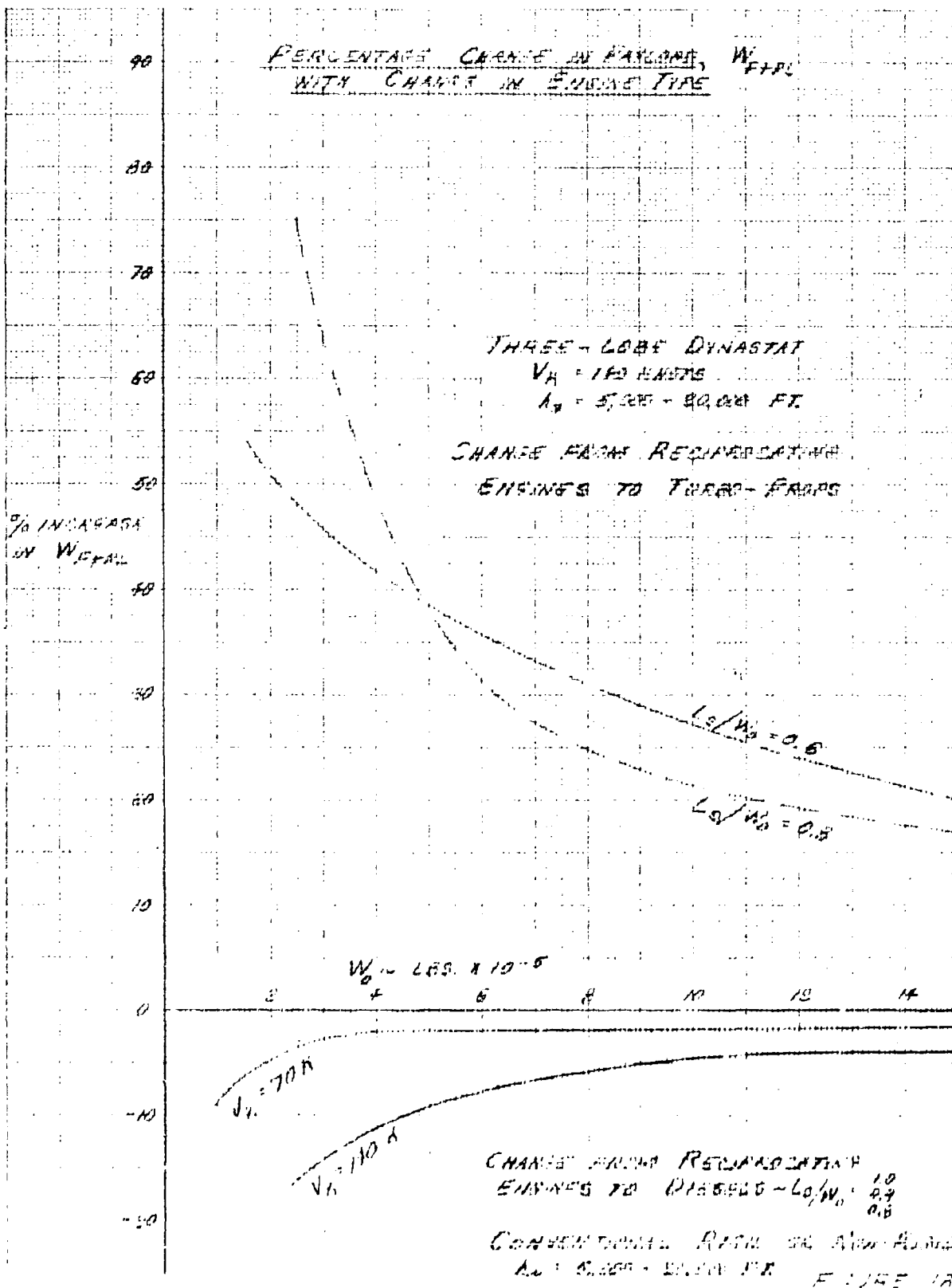
W₀ x 10⁻³

W₀ x 10⁻³

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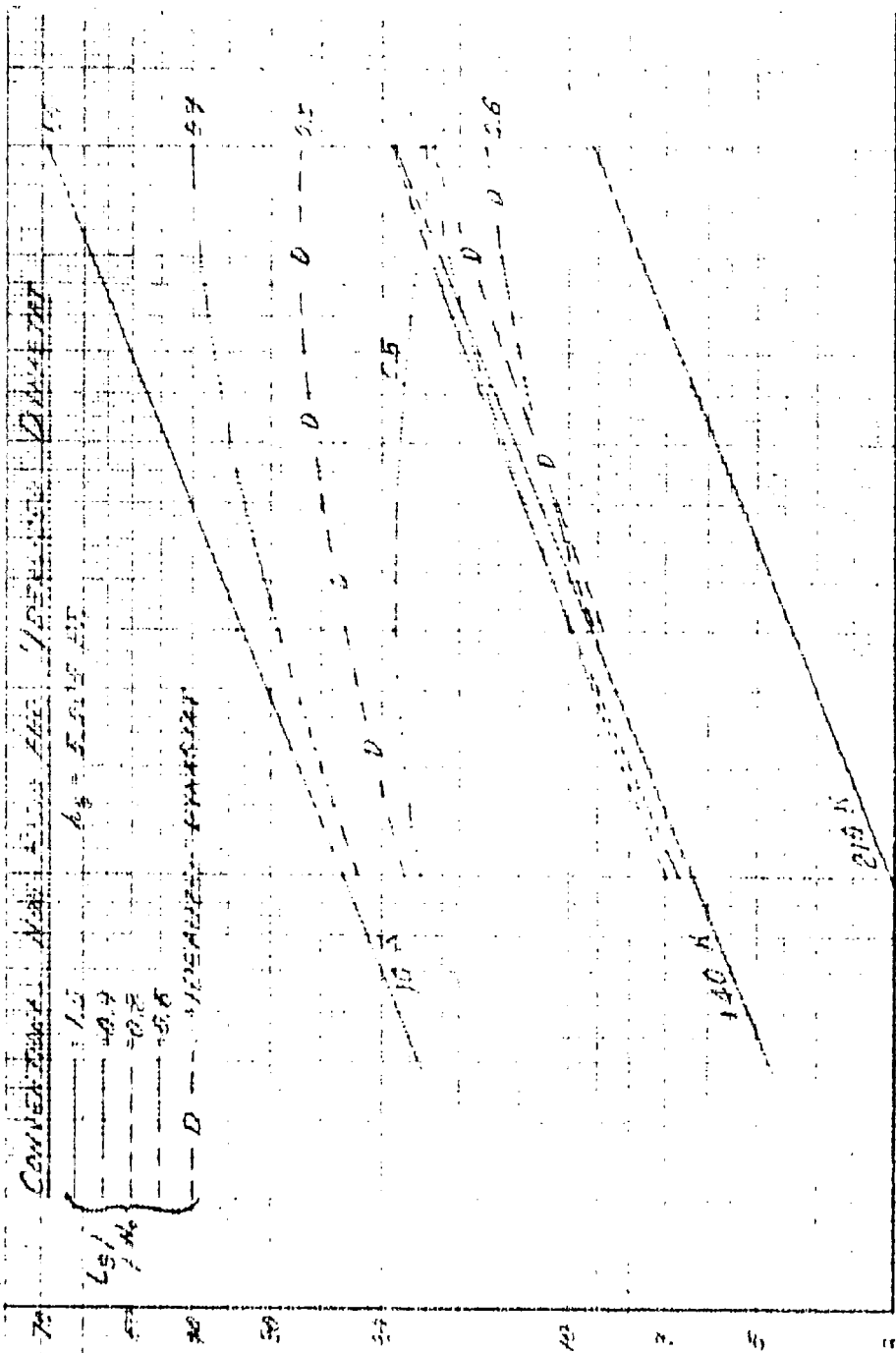


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100 200 400 700 1000

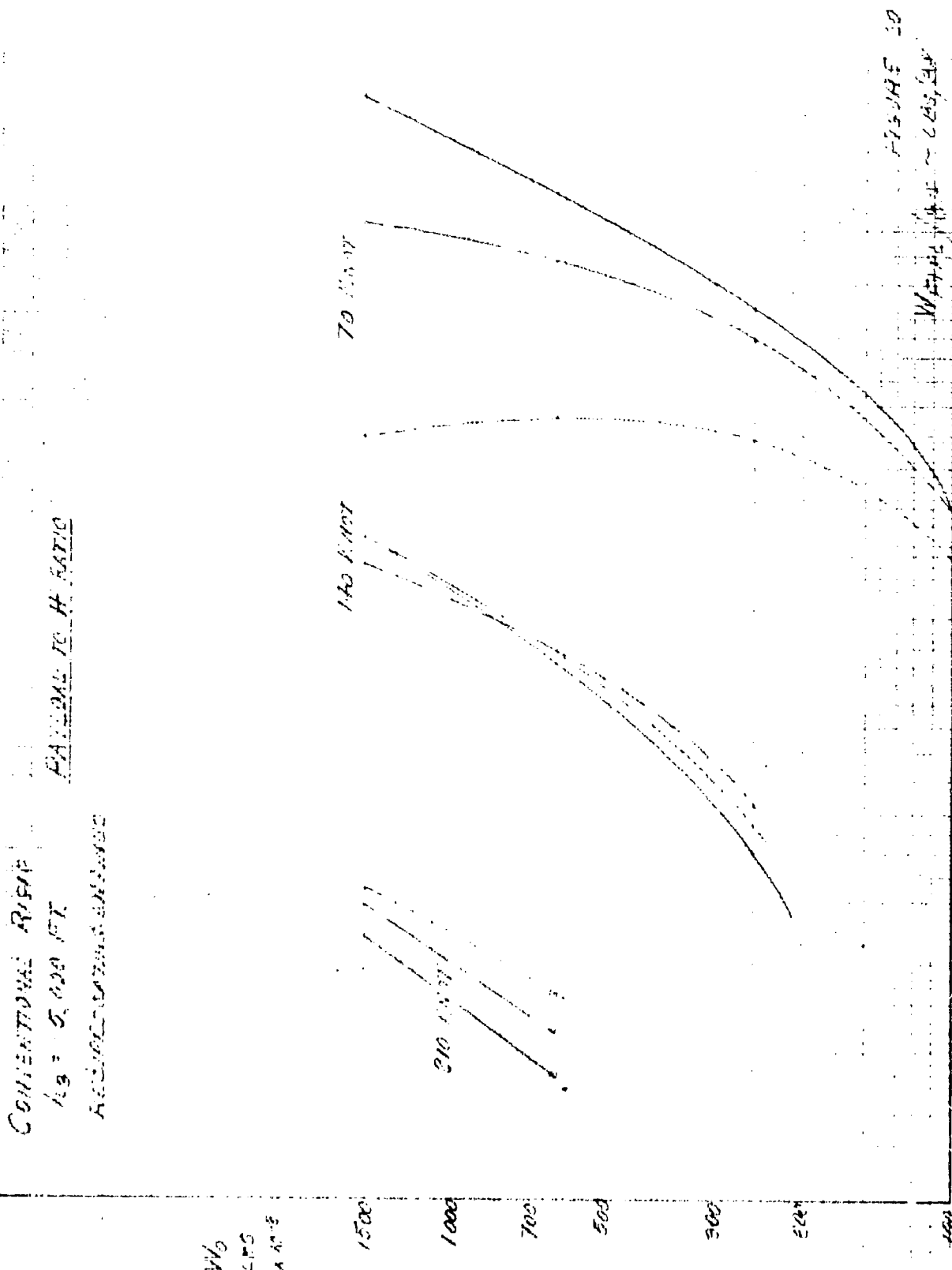
$M_0 = 1.0 \times 10^{-3}$

FIGURE 19

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1.5
 1.9
 0.8

WITHOUT
 WATER REMOVAL

PARTIAL TO H₂O

CONCENTRATION NON-RIGID

1000 PSI

RECAPACITORS ENGINES

75 H₂O

140 H₂O

210 H₂O

FIGURE 4

Water Vapor

100
 200
 300
 400
 500
 600
 700
 800
 900
 1000

100

200
 300
 400
 500
 600
 700
 800
 900
 1000

100
 200
 300
 400
 500
 600
 700
 800
 900
 1000

100
 200
 300
 400
 500
 600
 700
 800
 900
 1000

44

2000

Revised to HP 54710

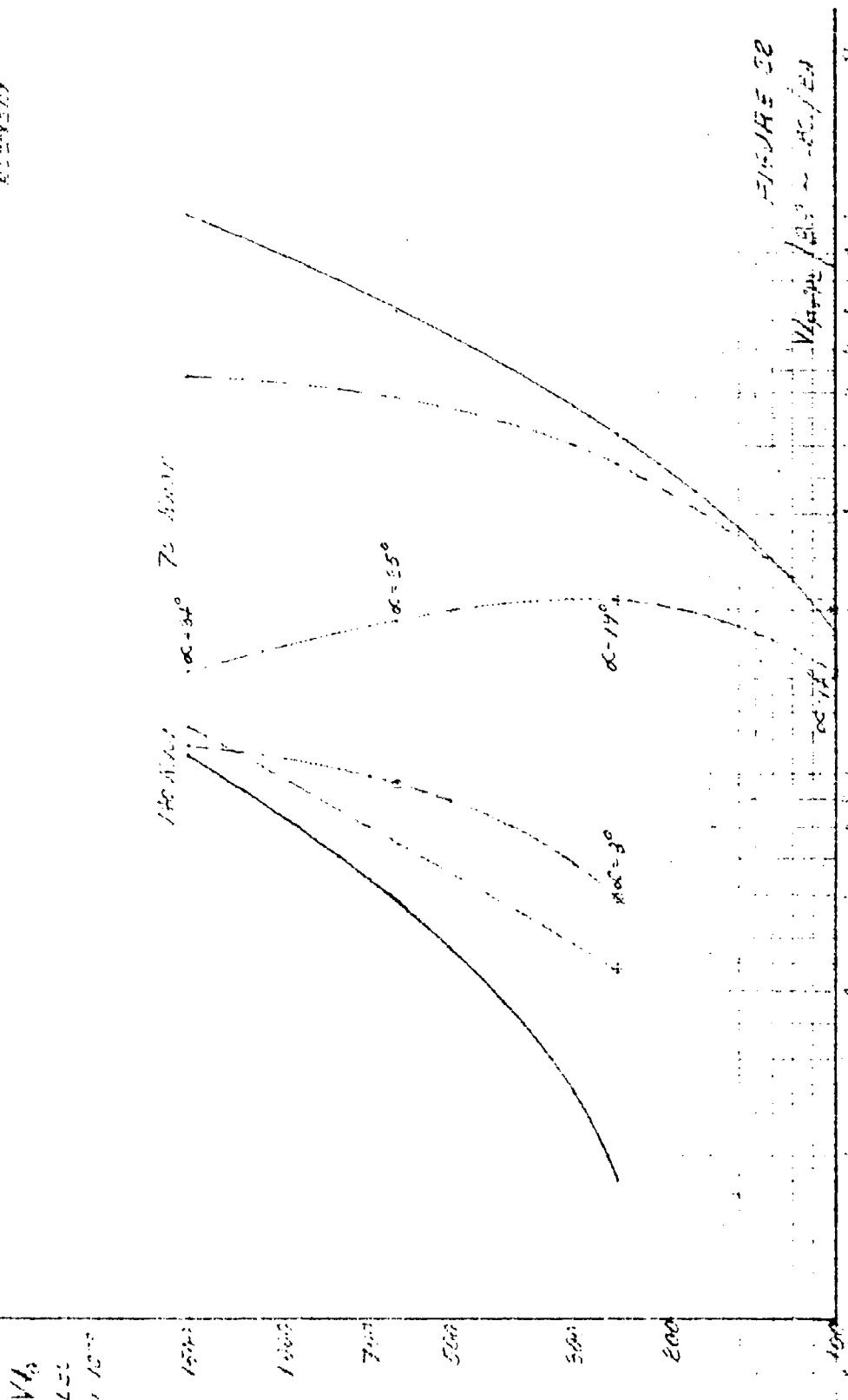
— 1.5
— 1.2
— 0.8

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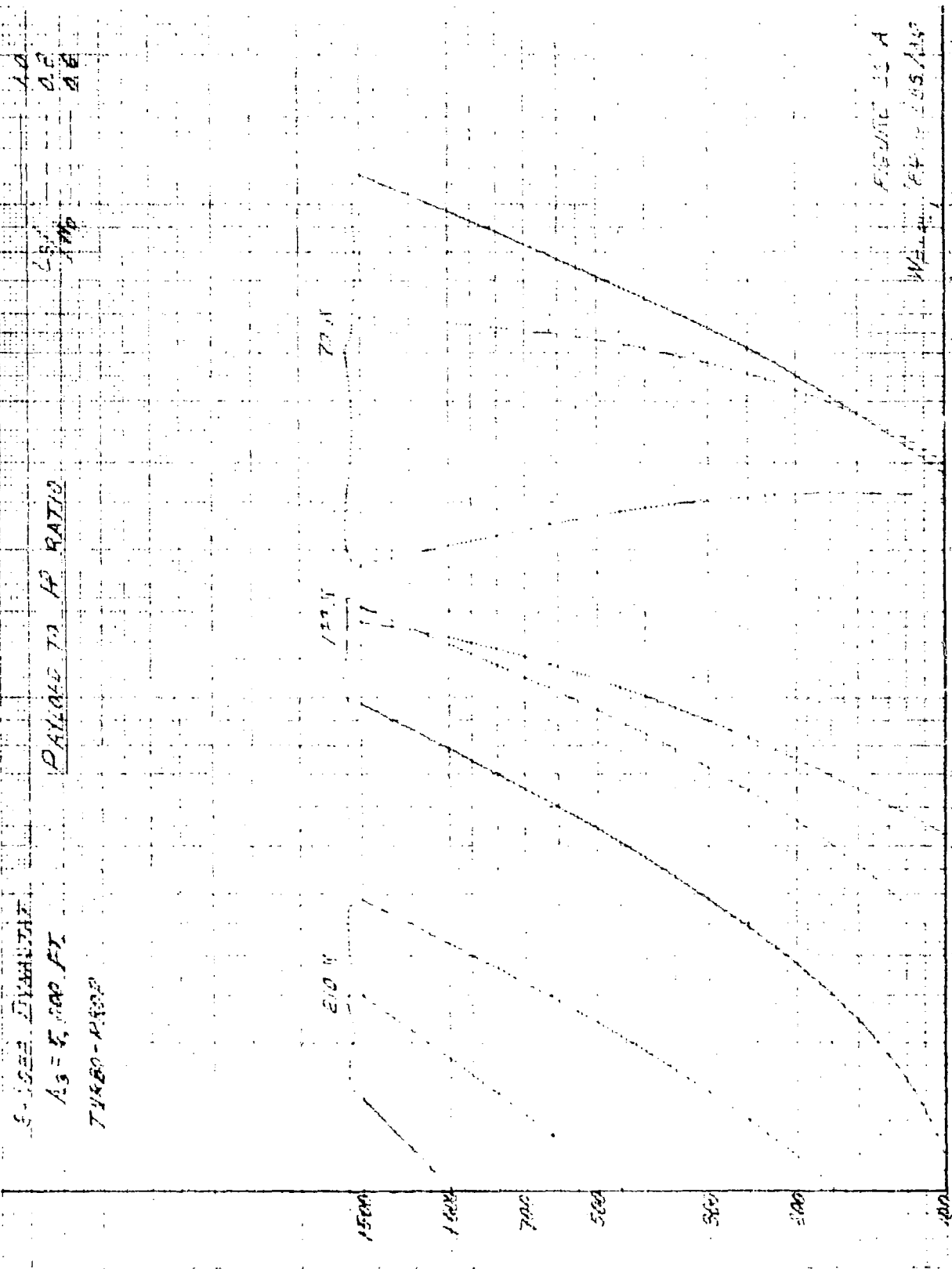


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$L_3/M_0 = 1.0$
 $L_3/M_0 = 0.4$
 $L_3/M_0 = 0.6$

WITH WATER
MSC-1447

PAVING TO 10 RATIO

$L_3 = 5,000$ FT

RECIPROCAL ENGINE

TO KNOT

140 KNOT

FIGURE 25

WATER/AF - 245/250

W_0

4.25

$\times 10^{-4}$

1500

1000

700

500

300

200

100

100

conventional rigid is superior to the non-rigid, primarily due to lower power-plant requirement. The minimum weight conventional ship capable of 210 knots with reciprocating engines, is about 300,000 pounds.

A study of Tables IV-40 and IV-47 results in some interesting comparisons. The rigid ship requires 93 percent of the W_0 power at W_3 ; the DYNASTAT ($L_s/W_0 = 0.6$) requires 87 percent of W_0 power at W_3 .

At 625,000 pounds gross weight (Tables IV-43 and IV-100) the spread is even greater. The rigid requires 87 percent power at W_3 compared to W_0 ; the DYNASTAT 76 percent.

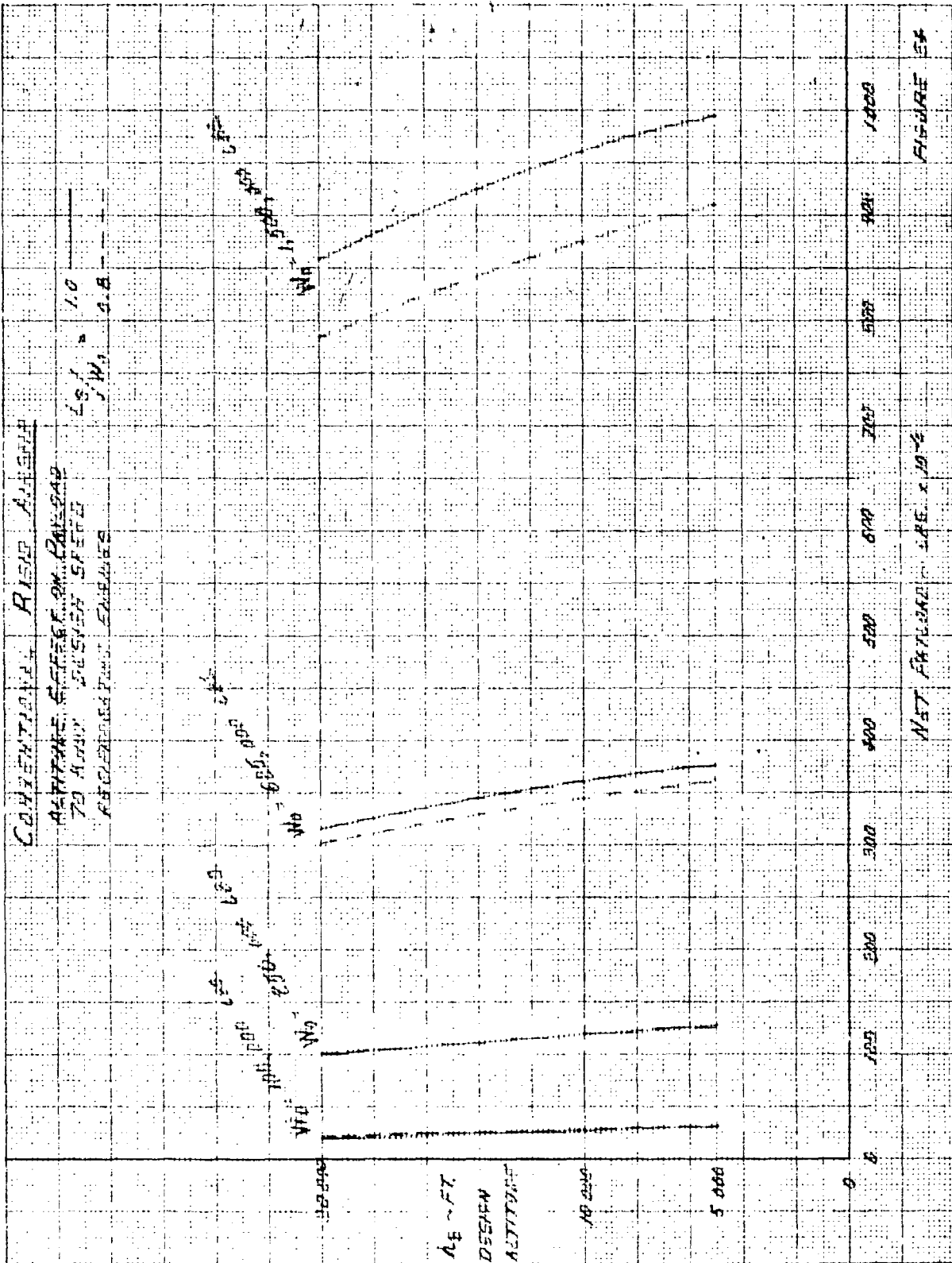
Figures 24-26 indicate the payload penalty paid for altitude capability, and the trends are similar for all type ships. Altitude works against the turbine as a power plant, on a weight basis. While 20,000 feet reduces the turbine's B.S.F.C. approximately 10 percent (to figures still higher than the reciprocating engine's best) installed horsepower must be about 180 percent of sea-level horsepower to compensate for the altitude degradation in horsepower output. Its installed weight thus becomes very similar to the reciprocating engine weight.

Figures 27 and 28 present the variation of speeds for best range and best endurance with gross weight. These plots appear nearly straight-line on a log-log plot, and of parallel slope with the exception of the speed for best range at the higher L_s/W_0 in each case (DYNASTAT and conventional).

Figure 29 is an iterative solution of a maximum endurance problem for a specific case. Fuel flows at W_0 , W_1 , W_2 , and W_3 (from Table IV-29) are plotted against time such that the cross-hatched areas under the curve equal $.25 (W_f + p_l)$ or 7,496.5 pounds, in this case. For any specific fuel weight allocation, say 20,000 pounds, a vertical cut-off between W_2 and W_3 giving total area under the curve of 20,000 pounds would represent total endurance for that fuel weight. Integration of the dotted velocity curve to the same vertical cut-off would result in total nautical miles covered.

The result of flying "heavy" at low speed is apparent from this figure. Fuel expenditure from W_0 to W_1 of 7,496.5 pounds results in 18 hours in the air

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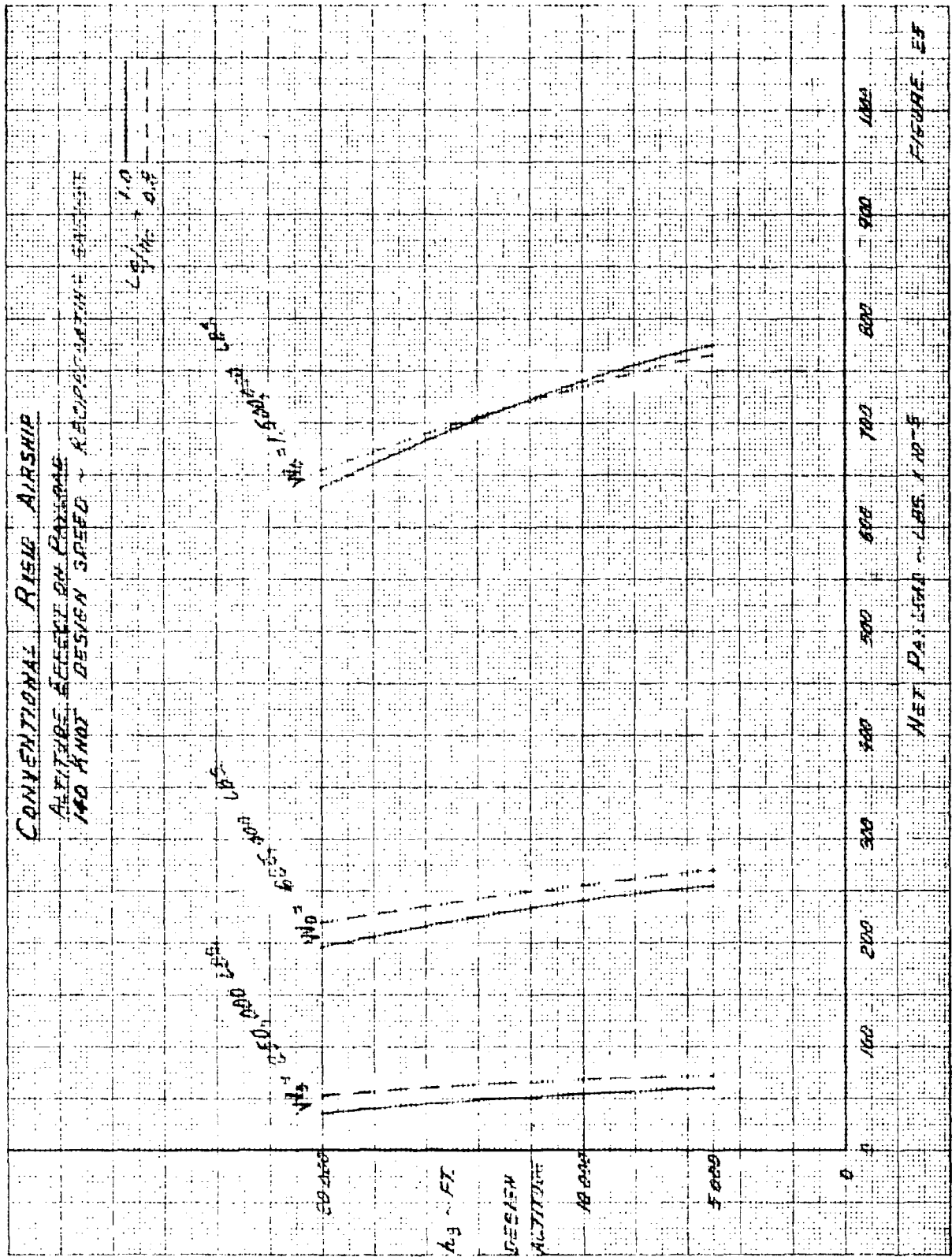
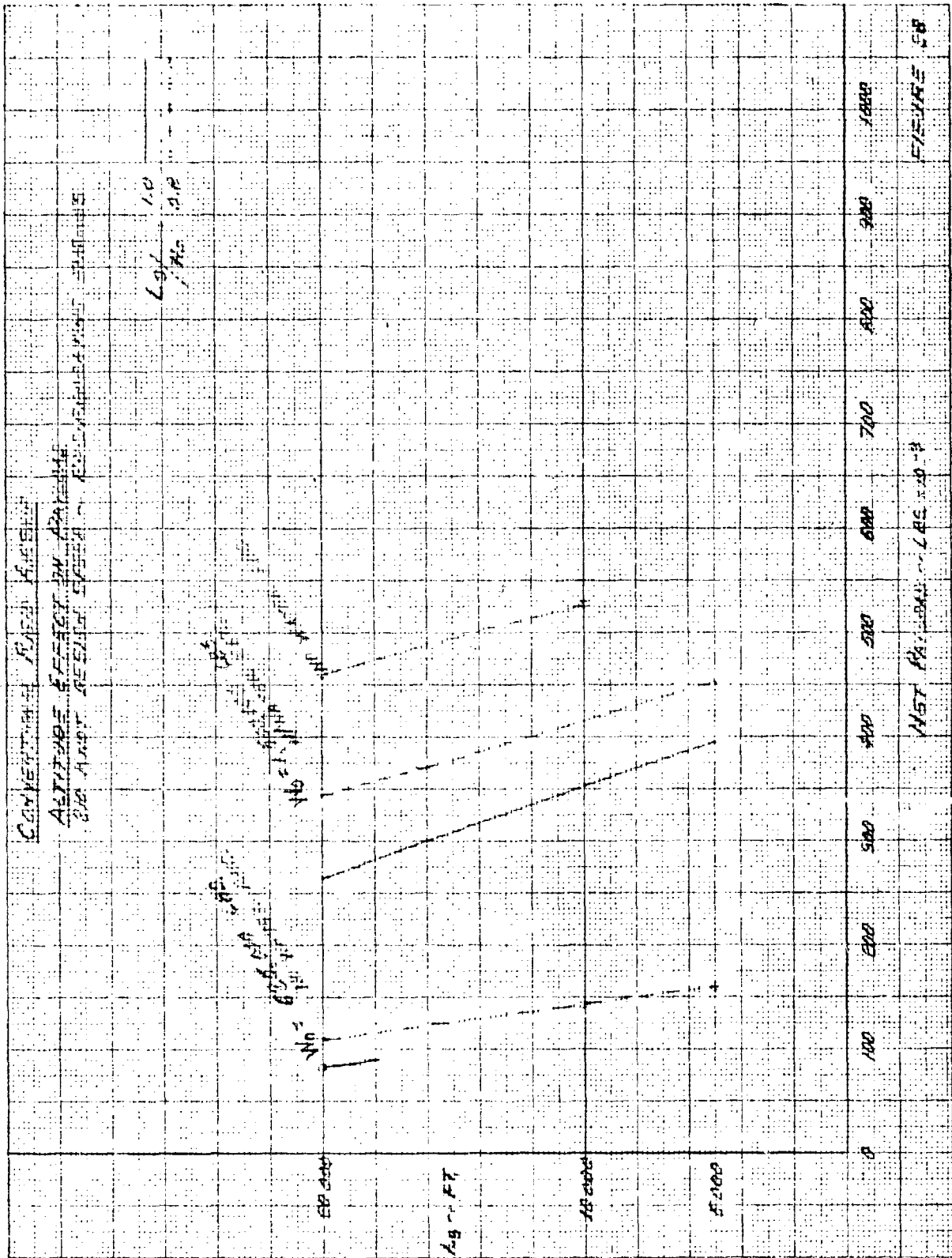


FIGURE 25



JR 223 (7-63)

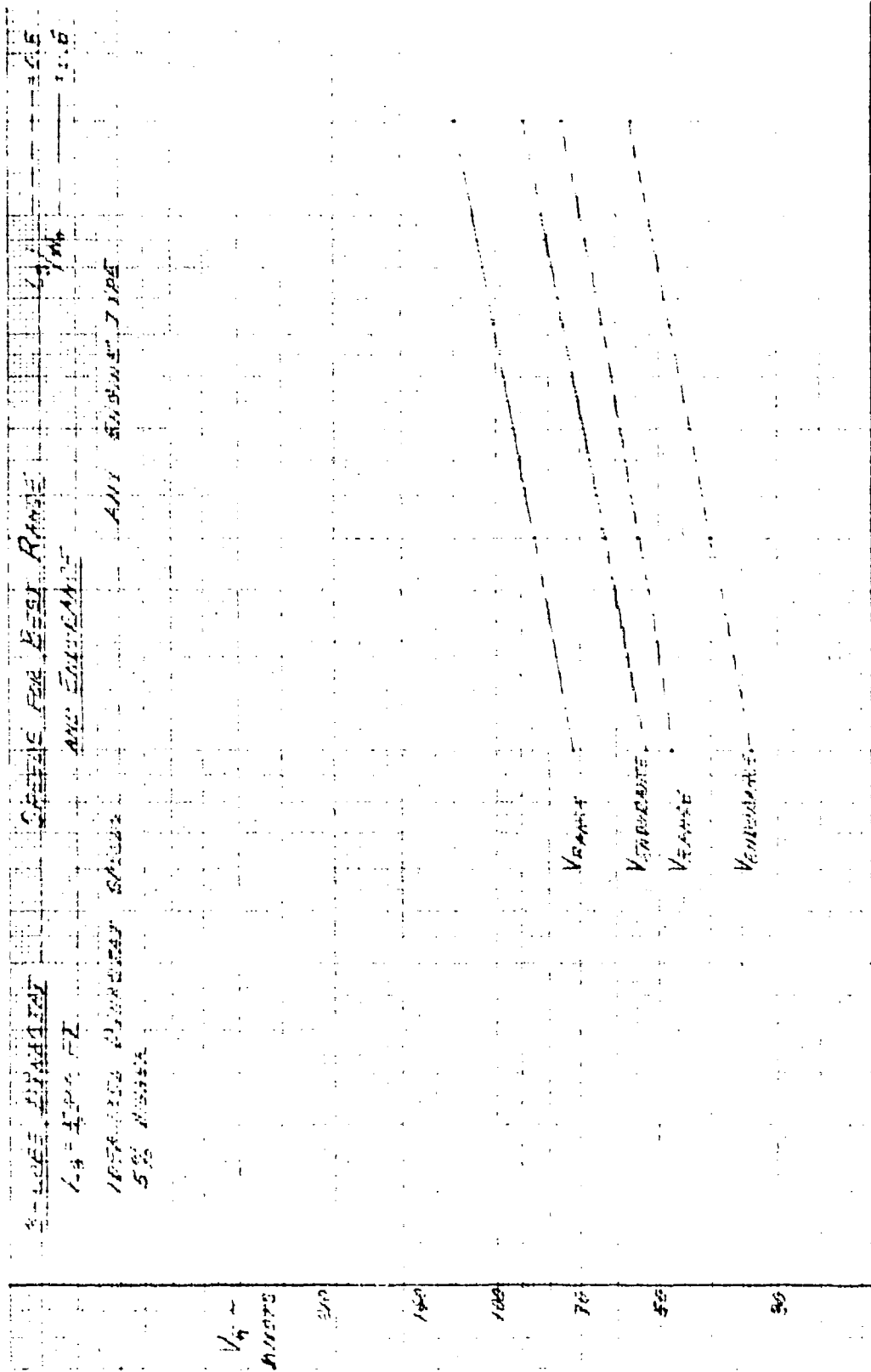
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27

JR 223 (7-63)

REF. ENGRG PROCEDURE S 017

CONVERTED TO: NO. 1000

AGE: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

AGE: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100

WHEELS: ENG. RANGE

AGE: ENG. RANGE

ANY ENGINE TYPE

AGE: 4.0
0.9
0.6

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25500

V_{H-1}
 HNOTS

510

140

100

70

50

30

V_{H-1} RANGE

V_{H-1} ENGINE RANGE

V_{H-1} RANGE

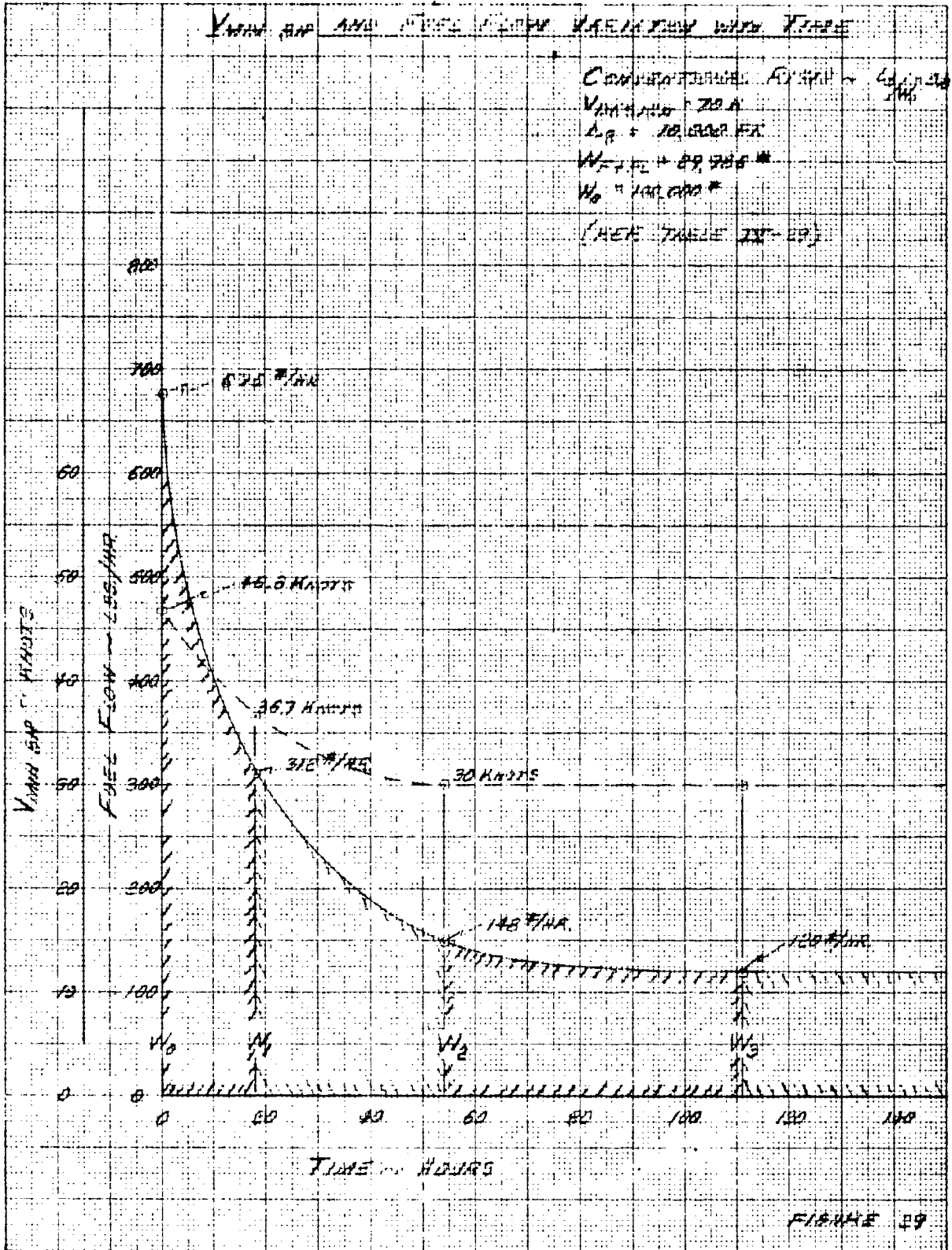
V_{H-1} ENGINE RANGE

V_{H-1}

100 200 300 400 500 600 700 800 900 1000

100 200 300 400 500 600 700 800 900 1000

FILE: 28



and 738 nautical miles covered. The same fuel weight from W_2 to W_3 permits 57 hours of flight and 1710 nautical miles, at a somewhat lower average speed.

Figure 49 presents the envelope of VTOL capability. This is based on the premise of swivelling propellers and the development of five pounds/BHP of static thrust, a conservative value. No conventional ships of 70-knot capability inherently had sufficient power to have VTOL capability at an $L_s/W_o = 0.9$. With 140-knot capability, VTOL is possible from W_o of 100,000 to 1,500,000 pounds for $L_s/W_o = 0.9$. For $L_s/W_o = 0.8$, up to a gross of 250,000 pounds VTOL is possible for a 140-knot-capable ship. Since in many cases a considerable change in gross weight can occur during a mission, vertical landing capability may be possible where vertical take off was not.

The 3-lobe DYNASTAT and the "idealized" DYNASTAT have VTOL capability at L_s/W_o of 0.8, $V_{max} = 140$ knots, through $W_o = 250,000$ through 1,500,000 pounds. The upper size may be marginal. None have VTOL capability on a static thrust basis for $L_s/W_o = 0.6$.

The selection of an appropriate airship type and configuration, and of its engines - type, size, etc. - is, as always, a matter requiring considerable definition of mission requirements. There is no all purpose airship. Permanent size and weight penalties are built-in for altitude capability or speed capability in all configurations.

If 70 knots and less is the speed regime, appreciably "heavy" flight is not desirable and a neutrally-buoyant or nearly-buoyant conventional rigid or non-rigid is the choice. At 140 knots, "heavy" flight is feasible and desirable and either a conventional or DYNASTAT may be considered. Total mission profile as well as size and ground-handling differences will influence choice.

The DYNASTAT, at W_o 's of 100,000 to 1,500,000 lbs., belongs in the higher speed regimes. It is most effectively powered by turbo-props in the 140 to 210 knot range. Whether any type of reballasting provision is needed depends upon the L_s/W_o ratio and the total allocation of fuel to be made. In other words, any ship - DYNASTAT or conventional - can dispense with reballasting provision if its mission is to be "heavy" from

take-off to landing. The conventional rigid at 210 knots with reciprocating engines must be relatively large, $W_o = 450,000$ pounds and volume of 5,000,000 cubic feet is a minimum for $L_s/W_o = 0.8$ and $h_3 = 5,000$ feet, and this size has no payload capability. The largest ships, $W_o = 1,500,000$ pounds lose about half their payload capability in providing 210 knot speed instead of 140 knot speed (see Figure 13).

The type of power plant and even individual horsepower sizes can well be dictated by careful study of the entire mission. If sustained high speeds (relative to design V_{max}) are to constitute the bulk of the mission time, Diesels could well outperform reciprocating engines from a fuel requirement standpoint. Turbines will outperform reciprocating engines on both a weight and fuel weight requirement, at sustained high power output. If take-off and high speed requirements are to involve a small percentage of mission time (meaning small percentage of total fuel allocation) then the bulk of the installed horse power might well be high-power turbo-props, with a small percentage of total horsepower in Diesel or reciprocating engines, and with water recovery apparatus for the latter for sustained low-speed cruising. The cruise engines would be power-sized for optimum B.S.F.C. at required cruise power output.

Optimum configuration may well be influenced by a velocity-time mission analysis. If a mission began with relatively high speed, followed by sustained low speed, a "heavy" DYNASTAT, designed to reach near-buoyancy before the low speed part of the mission, could be the optimum.

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CONVENTIONAL NON-RIGID

TABLE IV-1
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 100000. LBS DESIGN ALTITUDE, H3 = 5000. FT

WC = 100000. LBS			DESIGN ALTITUDE, H3 = 5000. FT					LS/WO			VOLUME			WF+PL		
1	2	3	4	5	6	7	8	9	10	11	12	VOLUME			WF+PL	
LS/WO		H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL	VOLUME			WF+PL	
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR	VOLUME			WF+PL	
1	1.0	5000.	70.0	1333.	881.	30.0	319.	122.	30.0	319.	122.	1827549.			43342.	
2	1.0	3000.	67.9	1290.	853.	30.0	325.	125.	30.0	325.	125.	1644793.			43995.	
3	1.0	1500.	66.4	1259.	832.	30.0	330.	127.	30.0	330.	127.	1462038.			43956.	
4	0.5	5000.	70.0	1393.	921.	30.1	635.	243.	44.4	761.	295.					
5	0.5	3000.	67.9	1349.	892.	30.0	622.	238.	43.3	746.	289.					
6	0.5	1500.	66.4	1317.	870.	30.0	613.	235.	42.4	735.	285.					
7	0.5	5000.	70.0	1255.	799.	30.0	312.	119.	30.0	312.	119.					
8	0.5	3000.	67.9	1214.	774.	30.0	318.	122.	30.0	318.	122.					
9	0.5	1500.	66.4	1185.	755.	30.0	322.	123.	30.0	322.	123.					
10	0.5	5000.	70.0	1255.	799.	30.0	312.	119.	30.0	312.	119.					
11	0.5	3000.	67.9	1214.	774.	30.0	318.	122.	30.0	318.	122.					
12	0.5	1500.	66.4	1185.	755.	30.0	322.	123.	30.0	322.	123.					
13	0.9	5000.	70.0	1255.	799.	30.0	312.	119.	30.0	312.	119.					
14	0.9	3000.	67.9	1214.	774.	30.0	318.	122.	30.0	318.	122.					
15	0.9	1500.	66.4	1185.	755.	30.0	322.	123.	30.0	322.	123.					
16	0.6	5000.	70.0	1772.	1171.	44.8	1464.	882.	62.1	1710.	1114.					
17	0.6	3000.	67.9	1717.	1135.	43.5	1426.	859.	60.4	1666.	1085.					
18	0.6	1500.	66.4	1677.	1108.	42.6	1398.	842.	59.2	1634.	1064.					
19	0.8	5000.	70.0	1295.	537.	30.0	588.	235.	44.2	708.	275.					
20	0.8	3000.	67.9	1253.	519.	30.0	577.	230.	43.0	695.	270.					
21	0.8	1500.	66.4	1223.	507.	30.0	570.	228.	42.2	685.	266.					
22	0.8	5000.	70.0	1173.	468.	30.0	304.	122.	30.3	308.	123.					
23	0.8	3000.	67.9	1135.	453.	30.0	310.	124.	30.0	310.	124.					
24	0.8	1500.	66.4	1108.	442.	30.0	314.	126.	30.0	314.	126.					
25	0.8	5000.	70.0	1173.	468.	30.0	304.	122.	30.3	308.	123.					
26	0.8	3000.	67.9	1135.	453.	30.0	310.	124.	30.0	310.	124.					
27	0.8	1500.	66.4	1108.	442.	30.0	314.	126.	30.0	314.	126.					

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TABLE IV-2
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 10000. FT			RECIPROCATING - COMPOUND ENGINE					
MC = 100000. LBS			DESIGN ALTITUDE, H3 = 10000. FT			LS/WO					
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGEI) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	10000.	70.0	1273.	796.	30.0	313.	122.	30.0	313.	122.
2	1-C	5000.	64.8	1170.	726.	30.0	330.	127.	30.0	330.	127.
3	1-C	1500.	61.5	1105.	686.	30.0	342.	132.	30.0	342.	132.
4	C-5	10000.	70.0	1343.	840.	30.9	646.	253.	45.5	774.	293.
5	C-9	5000.	64.8	1236.	767.	30.0	614.	234.	42.5	736.	284.
6	C-5	1500.	61.5	1168.	725.	30.0	597.	228.	40.6	711.	274.
7	C-9	10000.	70.0	1197.	595.	30.0	307.	122.	30.1	308.	122.
8	C-9	5000.	64.8	1101.	576.	30.0	322.	123.	30.0	322.	123.
9	C-5	1500.	61.5	1039.	544.	30.0	334.	128.	30.0	334.	128.
10	C-9	10000.	70.0	1197.	595.	30.0	307.	122.	30.1	308.	122.
11	C-9	5000.	64.8	1101.	576.	30.0	322.	123.	30.0	322.	123.
12	C-5	1500.	61.5	1039.	544.	30.0	334.	128.	30.0	334.	128.
13	C-9	10000.	70.0	1197.	595.	30.0	307.	122.	30.1	308.	122.
14	C-9	5000.	64.8	1101.	576.	30.0	322.	123.	30.0	322.	123.
15	C-5	1500.	61.5	1039.	544.	30.0	334.	128.	30.0	334.	128.
16	C-8	10000.	70.0	1749.	1094.	46.0	1497.	611.	63.7	1748.	1093.
17	C-8	5000.	64.8	1612.	1002.	42.6	1399.	615.	59.3	1635.	1075.
18	C-8	1500.	61.5	1526.	948.	40.5	1336.	588.	56.3	1563.	980.
19	C-8	10000.	70.0	1270.	494.	31.7	650.	254.	46.7	779.	311.
20	C-8	5000.	64.8	1168.	465.	30.0	616.	246.	43.6	742.	288.
21	C-8	1500.	61.5	1104.	439.	30.0	597.	238.	41.7	715.	278.
22	C-8	10000.	70.0	1118.	427.	30.0	299.	126.	30.9	308.	129.
23	C-8	5000.	64.8	1028.	399.	30.0	314.	126.	30.0	314.	126.
24	C-8	1500.	61.5	971.	377.	30.0	325.	131.	30.0	325.	131.
25	C-8	10000.	70.0	1118.	427.	30.0	299.	126.	30.9	308.	129.
26	C-8	5000.	64.8	1028.	399.	30.0	314.	126.	30.0	314.	126.
27	C-8	1500.	61.5	971.	377.	30.0	325.	131.	30.0	325.	131.

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TABLE IV-3
DESIGN VMAX = 70. KNOTS
CONVENTIONAL NON-RIGID RECIPROCATING - COMPUOND ENGINE

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 20000. FT			DESIGN VMAX = 70. KNOTS			RECIPROCATING - COMPUOND ENGINE		
1	2	3	4	5	6	7	8	9	10	11	12
LS/MO	W0	H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	WF+PL LBS/HR
1	1.0	20000.	70.0	1155.	622.	30.0	303.	120.	30.5	308.	31559.
2	1.0	10000.	59.5	967.	384.	30.0	337.	128.	30.0	337.	32573.
3	1.0	1500.	52.3	839.	334.	30.0	372.	141.	30.0	372.	32713.
4	0.9	20000.	70.0	1248.	672.	32.6	672.	264.	47.8	803.	
5	0.9	10000.	59.5	1047.	417.	30.0	603.	238.	41.4	721.	
6	0.9	1500.	52.3	910.	362.	30.0	573.	227.	36.9	665.	
7	0.9	20000.	70.0	1091.	418.	30.0	310.	124.	32.4	333.	131.
8	0.9	10000.	59.5	914.	355.	30.0	338.	130.	30.0	338.	130.
9	0.9	1500.	52.3	793.	308.	30.0	369.	142.	30.0	369.	142.
10	0.9	20000.	70.0	1086.	416.	30.0	297.	120.	31.2	308.	124.
11	0.9	10000.	59.5	909.	353.	30.0	329.	127.	30.0	329.	127.
12	0.9	1500.	52.3	789.	306.	30.0	362.	140.	30.0	362.	140.
13	0.9	20000.	70.0	1086.	416.	30.0	297.	120.	31.2	308.	124.
14	0.9	10000.	59.5	909.	353.	30.0	329.	127.	30.0	329.	127.
15	0.9	1500.	52.3	789.	306.	30.0	362.	140.	30.0	362.	140.
16	0.8	20000.	70.0	1717.	924.	48.5	1571.	609.	67.1	1833.	1139.
17	0.8	10000.	59.5	1446.	576.	41.4	1360.	534.	57.6	1591.	801.
18	0.8	1500.	52.3	1262.	503.	36.5	1216.	477.	51.0	1426.	719.
19	0.8	20000.	70.0	1259.	471.	36.9	829.	335.	53.0	983.	376.
20	0.8	10000.	59.5	1057.	402.	31.5	733.	298.	45.7	872.	341.
21	0.8	1500.	52.3	920.	350.	30.0	671.	273.	40.7	797.	311.
22	0.8	20000.	70.0	1037.	390.	30.0	345.	145.	36.4	401.	163.
23	0.8	10000.	59.5	868.	339.	30.0	360.	147.	32.2	384.	155.
24	0.8	1500.	52.3	754.	295.	30.0	381.	156.	30.0	381.	154.
25	0.8	20000.	70.0	1013.	382.	30.0	290.	126.	31.9	308.	132.
26	0.8	10000.	59.5	848.	334.	30.0	320.	134.	30.0	320.	134.
27	0.8	1500.	52.3	737.	290.	30.0	351.	147.	30.0	351.	147.

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TABLE IV-4
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 5000. FT			DESIGN VMAX = 70. KNOTS			RECIPROCATING - COMPOUND ENGINE			
WC = 250000. LBS			DESIGN ALTITUDE, H3 = 5000. FT			DESIGN VMAX = 70. KNOTS			RECIPROCATING - COMPOUND ENGINE			
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1-C	5000.	70.0	2281.	1507.	30.0	404.	161.	30.0	404.	161.	
2	1-C	3000.	67.9	2207.	1459.	30.0	415.	165.	30.0	415.	165.	
3	1-0	1500.	66.4	2154.	1424.	30.0	423.	169.	30.0	423.	169.	
4	0.9	5000.	70.0	2613.	1727.	36.0	1436.	556.	50.0	1678.	669.	
5	0.9	3000.	67.9	2529.	1672.	34.9	1398.	542.	48.6	1635.	651.	
6	0.9	1500.	66.4	2469.	1632.	34.2	1371.	531.	47.6	1603.	638.	
7	0.9	5000.	70.0	2143.	1284.	30.0	391.	161.	30.0	391.	161.	
8	0.9	3000.	67.9	2073.	1243.	30.0	402.	165.	30.0	402.	165.	
9	0.9	1500.	66.4	2023.	1213.	30.0	410.	168.	30.0	410.	168.	
10	0.9	5000.	70.0	2143.	1284.	30.0	391.	161.	30.0	391.	161.	
11	0.9	3000.	67.9	2073.	1243.	30.0	402.	165.	30.0	402.	165.	
12	0.9	1500.	66.4	2023.	1213.	30.0	410.	168.	30.0	410.	168.	
13	0.9	5000.	70.0	2143.	1284.	30.0	391.	161.	30.0	391.	161.	
14	0.9	3000.	67.9	2073.	1243.	30.0	402.	165.	30.0	402.	165.	
15	0.9	1500.	66.4	2023.	1213.	30.0	410.	168.	30.0	410.	168.	
16	0.8	5000.	70.0	4032.	2665.	53.6	3789.	2458.	72.7			
17	0.8	3000.	67.9	3908.	2583.	52.0	3680.	2387.	70.6			
18	0.8	1500.	66.4	3818.	2523.	50.9	3602.	2336.	69.1			
19	0.8	5000.	70.0	2150.	830.	30.0	732.	290.	39.7	864.	330.	
20	0.8	3000.	67.9	2081.	803.	30.0	721.	286.	38.7	846.	323.	
21	0.8	1500.	66.4	2031.	784.	30.0	714.	283.	37.9	833.	318.	
22	0.8	5000.	70.0	1999.	769.	30.0	378.	165.	30.0	378.	165.	
23	0.8	3000.	67.9	1934.	744.	30.0	388.	169.	30.0	388.	169.	
24	0.8	1500.	66.4	1887.	726.	30.0	395.	172.	30.0	395.	172.	
25	0.8	5000.	70.0	1999.	769.	30.0	378.	165.	30.0	378.	165.	
26	0.8	3000.	67.9	1934.	744.	30.0	388.	169.	30.0	388.	169.	
27	0.8	1500.	66.4	1887.	726.	30.0	395.	172.	30.0	395.	172.	

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TABLE IV-5
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID				DESIGN ALTITUDE, H3 = 10000. FT			RECIPROCATING - COMPOUND ENGINE				
W0 = 250000. LBS				DESIGN VMAX = 70. KNOTS							
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	10000.	70.0	2183.	1365.	30.0	395.	165.	30.0	395.	165.
2	1.0	5000.	64.8	2006.	1245.	30.0	423.	168.	30.0	423.	168.
3	1.0	1500.	61.5	1894.	1176.	30.0	445.	176.	30.0	445.	176.
4	0.9	10000.	70.0	2545.	1592.	36.9	1469.	556.	51.2	1716.	662.
5	0.9	5000.	64.8	2342.	1455.	34.2	1373.	529.	47.6	1605.	634.
6	0.9	1500.	61.5	2214.	1375.	32.5	1311.	505.	45.3	1535.	606.
7	0.9	10000.	70.0	2050.	814.	30.0	383.	165.	30.0	383.	165.
8	0.9	5000.	64.8	1884.	764.	30.0	410.	168.	30.0	410.	168.
9	0.9	1500.	61.5	1779.	722.	30.0	430.	176.	30.0	430.	176.
10	0.9	10000.	70.0	2050.	814.	30.0	383.	165.	30.0	383.	165.
11	0.9	5000.	64.8	1884.	764.	30.0	410.	168.	30.0	410.	168.
12	0.9	1500.	61.5	1779.	722.	30.0	430.	176.	30.0	430.	176.
13	0.8	10000.	70.0	2050.	814.	30.0	383.	165.	30.0	383.	165.
14	0.8	5000.	64.8	1884.	764.	30.0	410.	168.	30.0	410.	168.
15	0.8	1500.	61.5	1779.	722.	30.0	430.	176.	30.0	430.	176.
16	0.8	10000.	70.0	4053.	2535.	54.9	3886.	2323.	74.5	1009.	392.
17	0.8	5000.	64.8	3735.	2326.	50.9	3606.	2193.	69.1	952.	364.
18	0.8	1500.	61.5	3541.	2202.	48.4	3428.	2085.	65.7	916.	350.
19	0.8	10000.	70.0	2118.	812.	30.0	852.	345.	42.9	1009.	392.
20	0.8	5000.	64.8	1948.	746.	30.0	808.	318.	40.0	952.	364.
21	0.8	1500.	61.5	1841.	704.	30.0	786.	309.	38.1	916.	350.
22	0.8	10000.	70.0	1912.	754.	30.0	371.	169.	30.0	371.	169.
23	0.8	5000.	64.8	1757.	679.	30.0	395.	173.	30.0	395.	173.
24	0.8	1500.	61.5	1659.	641.	30.0	414.	181.	30.0	414.	181.
25	0.8	10000.	70.0	1912.	754.	30.0	371.	169.	30.0	371.	169.
26	0.8	5000.	64.8	1757.	679.	30.0	395.	173.	30.0	395.	173.
27	0.8	1500.	61.5	1659.	641.	30.0	414.	181.	30.0	414.	181.

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TABLE IV-6
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 20000. FT			RECIPROCATING - COMPOUND ENGINE									
1	2	3	4	5	6	7	8	9	10	11	12				
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/WO	VOLUME	WF+PL	
1	1.0	20000.	70.0	1991.	1072.	30.0	378.	160.	30.0	378.	160.	1.0	7384329.	122111.	
2	1.0	10000.	59.5	1666.	662.	30.0	437.	177.	30.0	437.	177.	0.9	6645894.	122227.	
3	1.0	1500.	52.3	1446.	575.	30.0	497.	201.	30.0	497.	201.	0.8	5907461.	118927.	
4	0.9	20000.	70.0	2421.	1303.	38.8	1543.	578.	53.8	1801.	675.				
5	0.9	10000.	59.5	2033.	809.	33.1	1336.	510.	46.2	1564.	597.				
6	0.9	1500.	52.3	1770.	704.	30.0	1196.	457.	40.9	1402.	535.				
7	0.9	20000.	70.0	1870.	705.	30.0	367.	161.	30.0	367.	161.				
8	0.9	10000.	59.5	1564.	597.	30.0	422.	179.	30.0	422.	179.				
9	0.9	1500.	52.3	1358.	518.	30.0	479.	203.	30.0	479.	203.				
10	0.9	20000.	70.0	1870.	705.	30.0	367.	161.	30.0	367.	161.				
11	0.9	10000.	59.5	1564.	597.	30.0	422.	179.	30.0	422.	179.				
12	0.9	1500.	52.3	1358.	518.	30.0	479.	203.	30.0	479.	203.				
13	0.8	20000.	70.0	1870.	705.	30.0	367.	161.	30.0	367.	161.				
14	0.8	10000.	59.5	1564.	597.	30.0	422.	179.	30.0	422.	179.				
15	0.8	1500.	52.3	1358.	518.	30.0	479.	203.	30.0	479.	203.				
16	0.8	20000.	70.0	4129.	2223.	57.9	4100.	1977.	78.4						
17	0.8	10000.	59.5	3486.	1391.	49.4	3500.	1399.	67.0						
18	0.8	1500.	52.3	3047.	1216.	43.5	3091.	1235.	59.2						
19	0.8	20000.	70.0	2135.	847.	36.2	1224.	461.	50.7	1435.	534.				
20	0.8	10000.	59.5	1791.	726.	30.9	1067.	415.	43.6	1255.	476.				
21	0.8	1500.	52.3	1558.	632.	30.0	970.	377.	38.6	1131.	429.				
22	0.8	20000.	70.0	1742.	725.	30.0	356.	166.	30.0	356.	166.				
23	0.8	10000.	59.5	1458.	564.	30.0	407.	185.	30.0	407.	185.				
24	0.8	1500.	52.3	1266.	490.	30.0	460.	209.	30.0	460.	209.				
25	0.8	20000.	70.0	1742.	725.	30.0	356.	166.	30.0	356.	166.				
26	0.8	10000.	59.5	1458.	564.	30.0	407.	185.	30.0	407.	185.				
27	0.8	1500.	52.3	1266.	490.	30.0	460.	209.	30.0	460.	209.				

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TABLE IV-7
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID				DESIGN VMAX = 70. KNOTS				RECIPROCATING - COMPOUND ENGINE			
W0 = 625000. LBS				DESIGN ALTITUDE, H3 = 5000. FT				LS/WO			
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	5000.	70.0	3947.	2609.	30.0	553.	229.	30.0	553.	229.
2	1-O	3000.	67.9	3819.	2524.	30.0	572.	237.	30.0	572.	237.
3	1-C	1500.	66.4	3727.	2464.	30.0	587.	244.	30.0	587.	244.
4	C-9	5000.	70.0	5299.	3503.	42.8	3720.	1512.	58.1	4303.	2556.
5	C-5	3000.	67.9	5132.	3392.	41.6	3613.	1469.	56.5	4181.	2483.
6	O-9	1500.	66.4	5011.	3312.	40.7	3536.	1438.	55.3	4092.	2431.
7	C-9	5000.	70.0	3704.	1503.	30.0	531.	230.	30.0	531.	230.
8	C-5	3000.	67.9	3584.	1454.	30.0	549.	238.	30.0	549.	238.
9	O-9	1500.	66.4	3498.	1419.	30.0	563.	244.	30.0	563.	244.
10	C-5	5000.	70.0	3704.	1503.	30.0	531.	230.	30.0	531.	230.
11	C-9	3000.	67.9	3584.	1454.	30.0	549.	238.	30.0	549.	238.
12	C-5	1500.	66.4	3498.	1419.	30.0	563.	244.	30.0	563.	244.
13	C-5	5000.	70.0	3704.	1503.	30.0	531.	230.	30.0	531.	230.
14	O-9	3000.	67.9	3584.	1454.	30.0	549.	238.	30.0	549.	238.
15	C-9	1500.	66.4	3498.	1419.	30.0	563.	244.	30.0	563.	244.
16	C-8	5000.	70.0	10352.	6842.	63.8	10421.	6902.	85.9	1381.	536.
17	C-6	3000.	67.9	10035.	6842.	62.0	10110.	6902.	83.4	1347.	536.
18	O-8	1500.	66.4	9607.	6483.	60.7	9887.	6548.	81.7	1323.	514.
19	C-8	5000.	70.0	3740.	1485.	30.0	1184.	475.	39.3	508.	226.
20	C-6	3000.	67.9	3620.	1485.	30.0	1161.	475.	38.2	525.	226.
21	O-8	1500.	66.4	3533.	1403.	30.0	1146.	460.	37.4	538.	239.
22	O-8	5000.	70.0	3451.	1328.	30.0	508.	226.	30.0	508.	226.
23	C-6	3000.	67.9	3339.	1328.	30.0	525.	226.	30.0	525.	226.
24	O-8	1500.	66.4	3258.	1254.	30.0	538.	239.	30.0	538.	239.
25	C-6	5000.	70.0	3451.	1328.	30.0	508.	226.	30.0	508.	226.
26	C-8	3000.	67.9	3339.	1328.	30.0	525.	226.	30.0	525.	226.
27	O-8	1500.	66.4	3258.	1254.	30.0	538.	239.	30.0	538.	239.

CONVENTIONAL NON-RIGID

TABLE IV-8
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 10000. FT

SAT - 000529 = 04

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	10000.	70.0	3784.	2367.	30.0	538.	233.	30.0	538.	233.
2	1-C	5000.	64.8	3478.	2158.	30.0	587.	242.	30.0	587.	242.
3	1-C	1500.	61.5	3284.	2038.	30.0	625.	258.	30.0	625.	258.
4	0-9	10000.	70.0	5230.	3271.	43.9	3817.	1488.	59.6	4414.	1790.
5	0-9	5000.	64.8	4918.	2994.	40.7	3542.	1409.	55.3	4099.	1709.
6	0-9	1500.	61.5	4557.	2831.	38.7	3367.	1340.	52.6	3898.	1626.
7	0-9	10000.	70.0	3551.	1373.	30.0	517.	234.	30.0	517.	234.
8	0-9	5000.	64.8	3263.	1284.	30.0	563.	244.	30.0	563.	244.
9	0-9	1500.	61.5	3081.	1212.	30.0	598.	259.	30.0	598.	259.
10	0-9	10000.	70.0	3551.	1373.	30.0	517.	234.	30.0	517.	234.
11	0-9	5000.	64.8	3263.	1284.	30.0	563.	244.	30.0	563.	244.
12	0-9	1500.	61.5	3081.	1212.	30.0	598.	259.	30.0	598.	259.
13	0-9	10000.	70.0	3551.	1373.	30.0	517.	234.	30.0	517.	234.
14	0-9	5000.	64.8	3263.	1284.	30.0	563.	244.	30.0	563.	244.
15	0-9	1500.	61.5	3081.	1212.	30.0	598.	259.	30.0	598.	259.
16	0-8	10000.	70.0	10572.	6613.	65.4	10700.	6732.	88.0		
17	0-8	5000.	64.8	9765.	6078.	60.7	9903.	6218.	81.7		
18	0-8	1500.	61.5	9253.	5759.	57.7	9396.	5900.	77.6		
19	0-8	10000.	70.0	3724.	1424.	31.1	1466.	595.	43.2	1713.	670.
20	0-8	5000.	64.8	3426.	1311.	30.0	1373.	543.	40.2	1603.	612.
21	0-8	1500.	61.5	3236.	1239.	30.0	1322.	523.	38.3	1533.	586.
22	0-8	10000.	70.0	3307.	1305.	30.0	496.	230.	30.0	496.	230.
23	0-8	5000.	64.8	3039.	1176.	30.0	538.	240.	30.0	538.	240.
24	0-8	1500.	61.5	2870.	1110.	30.0	571.	254.	30.0	571.	254.
25	0-8	10000.	70.0	3307.	1305.	30.0	496.	230.	30.0	496.	230.
26	0-8	5000.	64.8	3039.	1176.	30.0	538.	240.	30.0	538.	240.
27	0-8	1500.	61.5	2870.	1110.	30.0	571.	254.	30.0	571.	254.

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CONVENTIONAL NON-RIGID
DESIGN VMAX = 70. KNOTS
TABLE IV-9

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 20000. FT					RECIPROCATING - COMPOUND ENGINE				
DESIGN VMAX = 70. KNOTS												
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1-C	20000.	70.0	3464.	1865.	30.0	510.	225.	30.0	510.	225.	
2	1-O	10000.	59.5	2898.	1152.	30.0	612.	258.	30.0	612.	258.	
3	1-C	1500.	52.3	2515.	999.	30.0	718.	303.	30.0	718.	303.	
4	0-S	20000.	70.0	5121.	2757.	46.2	4030.	1524.	62.7	4661.	1806.	
5	0-S	10000.	59.5	4309.	1717.	39.4	3442.	1317.	53.6	3983.	1559.	
6	0-S	1500.	52.3	3756.	1497.	34.7	3039.	1163.	47.3	3520.	1378.	
7	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
8	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
9	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
10	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
11	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
12	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
13	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
14	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
15	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
16	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
17	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
18	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
19	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
20	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
21	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
22	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
23	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
24	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	
25	0-S	20000.	70.0	3249.	1217.	30.0	491.	227.	30.0	491.	227.	
26	0-S	10000.	59.5	2718.	1049.	30.0	587.	262.	30.0	587.	262.	
27	0-S	1500.	52.3	2359.	910.	30.0	685.	306.	30.0	685.	306.	

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TABLE IV-10
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID			DESIGN ALTITUDE, H3 = 5000. FT				RECIPROCATING - COMPOUND ENGINE				
W0 = 1500000. LBS											
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	70.0	6713.	4437.	30.0	801.	340.	30.0	801.	340.
2	1.0	W0	67.9	6495.	4293.	30.0	833.	354.	30.0	833.	354.
3	1.0	W0	66.4	6339.	4190.	30.0	858.	364.	30.0	858.	364.
4	0.9	W0	70.0	11421.	7549.	50.6	9787.	6029.	68.1	11282.	7419.
5	C.5	W0	67.9	11065.	7549.	49.1	9496.	6029.	66.1	10947.	7419.
6	C.5	W0	66.4	10808.	7144.	48.0	9286.	5720.	64.7	10705.	7040.
7	0.9	W1	70.0	6296.	2441.	30.0	763.	330.	30.0	763.	330.
8	C.5	W1	67.9	6092.	2441.	30.0	794.	330.	30.0	794.	330.
9	0.9	W1	66.4	5945.	2305.	30.0	817.	354.	30.0	817.	354.
10	0.9	W2	70.0	6296.	2441.	30.0	763.	330.	30.0	763.	330.
11	0.9	W2	67.9	6092.	2441.	30.0	794.	330.	30.0	794.	330.
12	0.5	W2	66.4	5945.	2305.	30.0	817.	354.	30.0	817.	354.
13	C.5	W3	70.0	6296.	2441.	30.0	763.	330.	30.0	763.	330.
14	0.9	W3	67.9	6092.	2441.	30.0	794.	330.	30.0	794.	330.
15	C.5	W3	66.4	5945.	2305.	30.0	817.	354.	30.0	817.	354.
16	0.8	W0	70.0	28035.	18531.	75.4	2495.	963.	42.9	2895.	1150.
17	C.8	W0	67.9	27188.	18531.	73.2	2425.	963.	41.7	2815.	1150.
18	C.8	W0	66.4	26577.	17567.	71.6	2375.	917.	40.8	2757.	1096.
19	0.8	W1	70.0	6622.	2539.	31.4	724.	321.	30.0	724.	321.
20	0.8	W1	67.9	6409.	2539.	30.5	753.	321.	30.0	753.	321.
21	0.8	W1	66.4	6256.	2399.	30.0	775.	343.	30.0	775.	343.
22	C.8	W2	70.0	5860.	2252.	30.0	724.	321.	30.0	724.	321.
23	0.8	W2	67.9	5670.	2252.	30.0	753.	321.	30.0	753.	321.
24	C.8	W2	66.4	5533.	2126.	30.0	775.	343.	30.0	775.	343.
25	C.8	W3	70.0	5860.	2252.	30.0	724.	321.	30.0	724.	321.
26	0.8	W3	67.9	5670.	2252.	30.0	753.	321.	30.0	753.	321.
27	C.8	W3	66.4	5533.	2126.	30.0	775.	343.	30.0	775.	343.

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TABLE IV-11
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID				RECIPROCATING - COMPOUND ENGINE									
DESIGN ALTITUDE, H3 = 10000. FT				DESIGN ALTITUDE, H3 = 10000. FT								DESIGN VMAX = 70. KNOTS	
WC = 1500000. LBS				DESIGN ALTITUDE, H3 = 10000. FT								DESIGN VMAX = 70. KNOTS	
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MO	H	VMAX	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WF+PL		
1 1.0	10000.	70.0	6442.	4030.	30.0	777.	344.	30.0	777.	344.	1330569.		
2 1.0	5000.	64.8	5921.	3674.	30.0	860.	362.	30.0	860.	362.	1000580.		
3 1.0	1500.	61.5	5591.	3469.	30.0	923.	389.	30.0	923.	389.	934665.		
4 0.5	10000.	70.0	11437.	7154.	51.8	10553.	4492.	69.7	11587.	7293.			
5 0.5	5000.	64.8	10547.	6558.	48.0	9305.	4635.	64.7	10726.	6740.			
6 0.5	1500.	61.5	9983.	6207.	45.6	8829.	4398.	61.5	10179.	6396.			
7 0.5	10000.	70.0	6041.	2310.	30.0	741.	335.	30.0	741.	335.			
8 0.5	5000.	64.8	5552.	2126.	30.0	819.	354.	30.0	819.	354.			
9 0.5	1500.	61.5	5243.	2007.	30.0	878.	380.	30.0	878.	380.			
10 0.5	10000.	70.0	6041.	2310.	30.0	741.	335.	30.0	741.	335.			
11 0.5	5000.	64.8	5552.	2126.	30.0	819.	354.	30.0	819.	354.			
12 0.5	1500.	61.5	5243.	2007.	30.0	878.	380.	30.0	878.	380.			
13 0.5	10000.	70.0	6041.	2310.	30.0	741.	335.	30.0	741.	335.			
14 0.5	5000.	64.8	5552.	2126.	30.0	819.	354.	30.0	819.	354.			
15 0.5	1500.	61.5	5243.	2007.	30.0	878.	380.	30.0	878.	380.			
16 0.8	10000.	70.0	28967.	18119.	77.2								
17 0.8	5000.	64.8	26780.	16677.	71.6								
18 0.8	1500.	61.5	25389.	15811.	68.0								
19 0.8	10000.	70.0	6764.	2756.	35.2	3263.	1339.	47.9	3778.	1501.			
20 0.8	5000.	64.8	6224.	2387.	32.7	3030.	1214.	44.5	3511.	1363.			
21 0.8	1500.	61.5	5882.	2256.	31.1	2882.	1155.	42.3	3340.	1297.			
22 0.8	10000.	70.0	5623.	2239.	30.0	703.	322.	30.0	703.	322.			
23 0.8	5000.	64.8	5168.	2016.	30.0	776.	340.	30.0	776.	340.			
24 0.8	1500.	61.5	4879.	1903.	30.0	831.	364.	30.0	831.	364.			
25 0.8	10000.	70.0	5623.	2239.	30.0	703.	322.	30.0	703.	322.			
26 0.8	5000.	64.8	5168.	2016.	30.0	776.	340.	30.0	776.	340.			
27 0.8	1500.	61.5	4879.	1903.	30.0	831.	364.	30.0	831.	364.			

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TABLE IV-12
DESIGN VMAX = 70. KNOTS

CONVENTIONAL NON-RIGID				DESIGN ALTITUDE, H3 = 20000. FT				RECIPROCATING - COMPOUND ENGINE				
W0 = 1500000. LBS												
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	20000.	70.0	5908.	3181.	30.0	729.	329.	30.0	729.	329.	
2	1.0	10000.	59.5	4943.	1964.	30.0	504.	390.	30.0	904.	390.	
3	1.0	1500.	52.3	4289.	1705.	30.0	1083.	467.	30.0	1083.	467.	
4	C.5	20000.	70.0	11554.	6220.	54.5	10640.	4132.	73.3			
5	C.5	10000.	59.5	9744.	3886.	46.5	9035.	3539.	62.6			
6	C.5	1500.	52.3	8511.	3394.	41.0	7937.	3109.	55.2			
7	0.9	20030.	70.0	5539.	2239.	30.0	696.	323.	30.0	696.	323.	
8	C.5	10000.	59.5	4634.	1910.	30.0	860.	385.	30.0	860.	385.	
9	0.9	1500.	52.3	4021.	1657.	30.0	1028.	460.	30.0	1028.	460.	
10	0.9	20000.	70.0	5539.	2239.	30.0	696.	323.	30.0	696.	323.	
11	C.5	10000.	59.5	4634.	1910.	30.0	860.	385.	30.0	860.	385.	
12	C.9	1500.	52.3	4021.	1657.	30.0	1028.	460.	30.0	1028.	460.	
13	0.9	20000.	70.0	5539.	2239.	30.0	696.	323.	30.0	696.	323.	
14	C.5	10000.	59.5	4634.	1910.	30.0	860.	385.	30.0	860.	385.	
15	0.9	1500.	52.3	4021.	1657.	30.0	1028.	460.	30.0	1028.	460.	
16	0.8	20000.	70.0	31177.	16784.	81.2						
17	C.8	10000.	59.5	26422.	10560.	69.3						
18	C.8	1500.	52.3	23167.	9259.	61.1						
19	C.8	20000.	70.0	7407.	2878.	43.0	5153.	1962.	58.2	5952.	2447.	
20	C.8	10000.	59.5	6226.	2484.	36.7	4392.	1728.	49.7	5076.	1929.	
21	0.8	1500.	52.3	5424.	2164.	32.3	3871.	1523.	43.9	4477.	1701.	
22	C.8	20000.	70.0	5154.	1962.	30.0	661.	312.	30.0	661.	312.	
23	C.8	10000.	59.5	4312.	1705.	30.0	814.	371.	30.0	814.	371.	
24	0.8	1500.	52.3	3742.	1479.	30.0	970.	443.	30.0	970.	443.	
25	C.8	20000.	70.0	5154.	1962.	30.0	661.	312.	30.0	661.	312.	
26	C.8	10000.	59.5	4312.	1705.	30.0	814.	371.	30.0	814.	371.	
27	C.8	1500.	52.3	3742.	1479.	30.0	970.	443.	30.0	970.	443.	

11/28/07

TABLE IV-13
DESIGN VMAX = 140. KNOTS

CLAUVENTIONAL NON-RIGID										RECIPROCATING - COMPOUND ENGINE				
DESIGN ALTITUDE, H3 = 5000. FT										DESIGN VMAX = 140. KNOTS				
W0 = 100000. LBS										LS/W0				
1	2	3	4	5	6	7	8	9	10	11	12			
LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR			
1	1.0	W0	5000.	7950.	5255.	30.0	319.	146.	30.0	319.	146.			
2	1.0	W0	3000.	7775.	5140.	30.0	325.	149.	30.0	325.	149.			
3	1.0	W0	1500.	7647.	5055.	30.0	330.	152.	30.0	330.	152.			
4	C.9	W0	5000.	7542.	4985.	30.1	635.	279.	44.4	761.	329.			
5	C.9	W0	3000.	7376.	4876.	30.0	622.	274.	43.3	746.	323.			
6	C.9	W0	1500.	7255.	4796.	30.0	613.	270.	42.4	735.	318.			
7	C.9	W1	5000.	7500.	4946.	30.0	397.	180.	35.8	456.	205.			
8	C.9	W1	3000.	7335.	4837.	30.0	398.	181.	34.9	451.	203.			
9	C.9	W1	1500.	7214.	4758.	30.0	399.	181.	34.3	447.	201.			
10	C.9	W2	5000.	7485.	4932.	30.0	312.	143.	30.0	312.	143.			
11	C.9	W2	3000.	7321.	4824.	30.0	318.	146.	30.0	318.	146.			
12	C.9	W2	1500.	7200.	4744.	30.0	323.	148.	30.0	323.	148.			
13	C.9	W3	5000.	7485.	4932.	30.0	312.	143.	30.0	312.	143.			
14	C.9	W3	3000.	7321.	4824.	30.0	318.	146.	30.0	318.	146.			
15	C.9	W3	1500.	7200.	4744.	30.0	322.	148.	30.0	322.	148.			
16	C.8	W0	5000.	7246.	4790.	44.8	1464.	567.	62.1	1710.	656.			
17	C.8	W0	3000.	7087.	4685.	43.5	1426.	552.	60.4	1666.	639.			
18	C.8	W0	1500.	6971.	4608.	42.6	1398.	542.	59.2	1634.	627.			
19	C.8	W1	5000.	7126.	4678.	37.7	972.	406.	53.4	1146.	466.			
20	C.8	W1	3000.	6970.	4575.	36.6	949.	396.	52.0	1119.	456.			
21	C.8	W1	1500.	6855.	4500.	35.8	932.	389.	50.9	1100.	448.			
22	C.8	W2	5000.	7046.	4603.	30.0	567.	251.	43.6	684.	298.			
23	C.8	W2	3000.	6891.	4500.	30.0	558.	247.	42.5	671.	292.			
24	C.8	W2	1500.	6778.	4428.	30.0	551.	244.	41.6	662.	288.			
25	C.8	W3	5000.	7005.	4566.	30.0	336.	153.	33.1	367.	167.			
26	C.8	W3	3000.	6851.	4465.	30.0	340.	155.	32.4	365.	166.			
27	C.8	W3	1500.	6738.	4392.	30.0	343.	157.	31.9	363.	165.			

CONVENTIONAL NON-RIGID

DESIGN VMAX = 14C. KNÜTS

TABLE IV-14

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 10000. FT																																						
WC = 100000. LBS			1			2			3			4			5			6			7			8			9			10			11			12		
LS/MG			H FT.			VMAX KNOTS			BHP			FUEL LBS/HR			V(MIN BHP) KNOTS			BHP			FUEL LBS/HR			V(MAX RGE) KNOTS			BHP			FUEL LBS/HR			VOLUME 2132175. 1918936. 1705738.			WF+PL 13043. 16282. 19571.		
1	2	3	4	5	6	7	8	9	10	11	12																											
1	1.0	MO	10000.	7582.	4743.	30.0	313.	149.	30.0	313.	149.																											
2	1.0	MO	5000.	7158.	4517.	30.0	330.	151.	30.0	330.	151.																											
3	1.0	MO	1500.	6879.	4341.	30.0	342.	157.	30.0	342.	157.																											
4	0.9	MO	10000.	7195.	4501.	30.9	646.	294.	45.5	774.	347.																											
5	0.9	MO	5000.	6794.	4287.	30.0	614.	271.	42.5	736.	320.																											
6	0.9	MO	1500.	6529.	4120.	30.0	597.	263.	40.6	711.	309.																											
7	0.9	M1	10000.	7156.	4465.	30.0	426.	200.	38.0	504.	234.																											
8	0.9	M1	5000.	6757.	4249.	30.0	425.	192.	35.7	487.	219.																											
9	0.9	M1	1500.	6493.	4083.	30.0	426.	193.	34.2	476.	214.																											
10	0.9	M2	10000.	7137.	4448.	30.0	318.	151.	31.3	331.	157.																											
11	0.9	M2	5000.	6739.	4231.	30.0	332.	152.	30.0	332.	152.																											
12	0.9	M2	1500.	6476.	4066.	30.0	343.	157.	30.0	343.	157.																											
13	0.9	M3	10000.	7135.	4446.	30.0	307.	146.	30.1	308.	146.																											
14	0.9	M3	5000.	6737.	4229.	30.0	322.	148.	30.0	322.	148.																											
15	0.9	M3	1500.	6474.	4064.	30.0	334.	153.	30.0	334.	153.																											
16	0.8	MO	10000.	6929.	4334.	46.0	1497.	603.	63.7	1748.	677.																											
17	0.8	MO	5000.	6544.	4130.	42.6	1399.	549.	59.3	1635.	625.																											
18	0.8	MO	1500.	6290.	3969.	40.5	1336.	525.	56.4	1563.	598.																											
19	0.8	M1	10000.	6817.	4228.	39.7	1054.	453.	56.0	1240.	513.																											
20	0.8	M1	5000.	6437.	4021.	36.8	989.	413.	52.1	1166.	474.																											
21	0.8	M1	1500.	6187.	3865.	35.0	948.	396.	49.7	1118.	455.																											
22	0.8	M2	10000.	6736.	4112.	32.4	676.	306.	47.4	808.	359.																											
23	0.8	M2	5000.	6361.	3944.	30.0	640.	281.	44.3	767.	330.																											
24	0.8	M2	1500.	6113.	3790.	30.0	619.	271.	42.3	741.	319.																											
25	0.8	M3	10000.	6687.	4042.	30.0	401.	188.	37.9	474.	220.																											
26	0.8	M3	5000.	6314.	3897.	30.0	401.	182.	35.7	460.	207.																											
27	0.8	M3	1500.	6068.	3745.	30.0	403.	193.	34.2	450.	202.																											

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TABLE IV-15
DESIGN VMAX = 140 KNOTS

CONVENTIONAL NON-RIGID				DESIGN ALTITUDE, H3 = 20000. FT				DESIGN VMAX = 140. KNOTS				RECIPROCATING - COMPOUND ENGINE			
WC = 100000. LBS	1	2	3	4	5	6	7	8	9	10	11	12	WF+PL		
LS/WO	LS/WO	LS/WO	H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR			
1	1.0	WC	20000.	140.0	6973.	3700.	30.0	303.	146.	30.5	309.	149.	6253.		
2	1.0	WC	10000.	118.9	6077.	2474.	30.0	337.	160.	30.0	337.	160.	9538.		
3	1.0	WC	1500.	104.5	5488.	2234.	30.0	372.	176.	30.0	372.	176.	13074.		
4	0.9	WC	20000.	140.0	6530.	3515.	32.6	672.	309.	47.8	803.	363.			
5	0.9	WC	10000.	118.9	5775.	2352.	30.0	603.	275.	41.4	721.	323.			
6	0.9	WC	1500.	104.5	5215.	2124.	30.0	573.	261.	36.9	665.	298.			
7	0.9	W1	20000.	140.0	6502.	3278.	30.0	517.	242.	43.1	626.	289.			
8	0.9	W1	10000.	118.9	5749.	2337.	30.0	488.	226.	37.6	572.	262.			
9	0.9	W1	1500.	104.5	5192.	2110.	30.0	485.	224.	33.7	535.	245.			
10	0.9	W2	20000.	140.0	6481.	3107.	30.0	401.	191.	38.4	477.	225.			
11	0.9	W2	10000.	118.9	5731.	2326.	30.0	404.	189.	33.7	447.	208.			
12	0.9	W2	1500.	104.5	5176.	2101.	30.0	420.	197.	30.5	426.	198.			
13	0.9	W3	20000.	140.0	6468.	2999.	30.0	328.	157.	33.9	364.	174.			
14	0.9	W3	10000.	118.9	5720.	2319.	30.0	351.	166.	30.2	354.	167.			
15	0.9	W3	1500.	104.5	5165.	2094.	30.0	379.	179.	30.0	379.	179.			
16	0.8	WC	20000.	140.0	6324.	3405.	48.5	1571.	630.	67.1	1833.	697.			
17	0.8	WC	10000.	118.9	5596.	2279.	41.4	1360.	553.	57.6	1591.	623.			
18	0.8	WC	1500.	104.5	5057.	2060.	36.5	1216.	494.	51.0	1426.	552.			
19	0.8	W1	20000.	140.0	6237.	2678.	44.2	1253.	527.	61.8	1467.	598.			
20	0.8	W1	10000.	118.9	5518.	2234.	37.7	1091.	462.	53.1	1282.	527.			
21	0.8	W1	1500.	104.5	4985.	2018.	33.2	980.	415.	47.1	1155.	475.			
22	0.8	W2	20000.	140.0	6166.	2445.	39.5	963.	423.	56.0	1135.	487.			
23	0.8	W2	10000.	118.9	5454.	2197.	33.7	846.	371.	48.3	1001.	430.			
24	0.8	W2	1500.	104.5	4927.	1984.	30.0	766.	336.	42.9	910.	390.			
25	0.8	W3	20000.	140.0	6110.	2412.	34.2	705.	322.	49.8	841.	376.			
26	0.8	W3	10000.	118.9	5404.	2168.	30.0	628.	285.	43.1	753.	335.			
27	0.8	W3	1500.	104.5	4881.	1958.	30.0	589.	267.	38.5	693.	308.			

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TABLE IV-16
DESIGN VMAX = 140. KNOTS

CONVENTIONAL NON-RIGID

RECIPROCATING - COMPOUND ENGINE

WC = 250000. LBS

DESIGN ALTITUDE, H3 = 5000. FT

	1	2	3	4	5	6	7	8	9	10	11	12
	LS/WC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	W0	5000.	140.0	13559.	8962.	30.0	404.	185.	30.0	404.	185.
2	1-C	W0	3000.	135.9	13259.	8862.	30.0	415.	185.	30.0	415.	185.
3	1-C	W0	1500.	132.9	13040.	8619.	30.0	423.	194.	30.0	423.	194.
4	C-5	W0	5000.	140.0	12935.	8550.	36.0	1436.	579.	50.0	1678.	656.
5	C-5	W0	3000.	135.9	12650.	8250.	34.9	1398.	579.	48.6	1635.	656.
6	C-5	W0	1500.	132.9	12441.	8224.	34.2	1371.	553.	47.6	1603.	627.
7	C-5	W1	5000.	140.0	12747.	8374.	30.0	422.	192.	30.0	422.	192.
8	C-5	W1	3000.	135.9	12466.	8374.	30.0	431.	192.	30.0	431.	192.
9	C-5	W1	1500.	132.9	12259.	8054.	30.0	437.	199.	30.0	437.	199.
10	C-5	W2	5000.	140.0	12742.	8369.	30.0	391.	179.	30.0	391.	179.
11	C-5	W2	3000.	135.9	12460.	8369.	30.0	402.	179.	30.0	402.	179.
12	C-5	W2	1500.	132.9	12254.	8049.	30.0	410.	187.	30.0	410.	187.
13	C-5	W3	5000.	140.0	12742.	8369.	30.0	391.	179.	30.0	391.	179.
14	C-5	W3	3000.	135.9	12460.	8369.	30.0	402.	179.	30.0	402.	179.
15	C-5	W3	1500.	132.9	12254.	8049.	30.0	410.	187.	30.0	410.	187.
16	C-6	W0	5000.	140.0	12726.	8412.	53.6	3789.	1450.	72.7	4349.	1676.
17	C-6	W0	3000.	135.9	12447.	8412.	52.0	3680.	1450.	70.6	4250.	1676.
18	C-6	W0	1500.	132.9	12243.	8093.	50.9	3602.	1378.	69.1	4167.	1606.
19	C-6	W1	5000.	140.0	12144.	7894.	39.4	1650.	657.	54.3	1969.	754.
20	C-6	W1	3000.	135.9	11877.	7894.	38.2	1645.	657.	52.9	1918.	754.
21	C-6	W1	1500.	132.9	11681.	7593.	37.4	1612.	627.	51.7	1880.	720.
22	C-6	W2	5000.	140.0	11898.	7711.	30.0	430.	196.	30.0	430.	196.
23	C-6	W2	3000.	135.9	11636.	7711.	30.0	437.	196.	30.0	437.	196.
24	C-6	W2	1500.	132.9	11443.	7416.	30.0	442.	201.	30.0	442.	201.
25	C-6	W3	5000.	140.0	11889.	7704.	30.0	378.	173.	30.0	378.	173.
26	C-6	W3	3000.	135.9	11627.	7704.	30.0	388.	173.	30.0	388.	173.
27	C-6	W3	1500.	132.9	11434.	7410.	30.0	395.	181.	30.0	395.	181.

11/28/67

TABLE IV-17
DESIGN VMAX = 140. KNOTS

CONVENTIONAL NON-RIGID

RECIPROCATING - COMPOUND ENGINE

WC = 250000. LBS			DESIGN ALTITUDE, H3 = 10000. FT								
1	2	3	4	5	6	7	8	9	10	11	12
LS/WC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGF) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	10000.	140.0	12970.	8113.	30.0	395.	187.	30.0	395.	187.
2	1.0	5000.	129.6	12244.	7725.	30.0	423.	193.	30.0	423.	193.
3	1.0	1500.	123.0	11764.	7422.	30.0	445.	203.	30.0	445.	203.
4	0.5	10000.	140.0	12389.	7750.	36.9	1469.	615.	51.2	1716.	697.
5	0.5	5000.	129.6	11696.	7380.	34.2	1373.	560.	47.6	1605.	635.
6	0.5	1500.	123.0	11239.	7092.	32.5	1311.	535.	45.3	1535.	608.
7	0.9	10000.	140.0	12197.	7572.	30.0	449.	211.	30.0	449.	211.
8	0.9	5000.	129.6	11514.	7194.	30.0	466.	211.	30.0	466.	211.
9	0.9	1500.	123.0	11063.	6912.	30.0	481.	218.	30.0	481.	218.
10	0.5	10000.	140.0	12185.	7555.	30.0	383.	181.	30.0	383.	181.
11	0.5	5000.	129.6	11503.	7182.	30.0	410.	187.	30.0	410.	187.
12	0.5	1500.	123.0	11052.	6901.	30.0	430.	196.	30.0	430.	196.
13	0.5	10000.	140.0	12185.	7555.	30.0	383.	181.	30.0	383.	181.
14	0.9	5000.	129.6	11503.	7182.	30.0	410.	187.	30.0	410.	187.
15	0.5	1500.	123.0	11052.	6901.	30.0	430.	196.	30.0	430.	196.
16	0.8	10000.	140.0	12247.	7601.	54.9	3886.	1528.	74.5	4436.	1688.
17	0.8	5000.	129.6	11567.	7300.	50.9	3606.	1387.	69.1	4172.	1602.
18	0.8	1500.	123.0	11118.	7017.	48.4	3428.	1318.	65.7	3967.	1523.
19	0.8	10000.	140.0	11667.	6900.	41.6	1866.	741.	57.2	2172.	829.
20	0.8	5000.	129.6	11016.	6745.	38.6	1740.	675.	53.2	2027.	777.
21	0.8	1500.	123.0	10586.	6482.	36.6	1659.	644.	50.6	1934.	741.
22	0.8	10000.	140.0	11391.	6575.	30.0	515.	240.	34.1	572.	265.
23	0.8	5000.	129.6	10754.	6487.	30.0	519.	234.	31.9	550.	247.
24	0.8	1500.	123.0	10333.	6234.	30.0	526.	237.	30.6	535.	240.
25	0.8	10000.	140.0	11366.	6550.	30.0	371.	176.	30.0	371.	176.
26	0.8	5000.	129.6	10729.	6464.	30.0	395.	181.	30.0	395.	181.
27	0.8	1500.	123.0	10310.	6211.	30.0	414.	189.	30.0	414.	189.

11/28/67

CONVENTIONAL NON-RIGID

TABLE IV-18
DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 250000. LBS DESIGN ALTITUDE, H3 = 20000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO	H	FT.	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL
			KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR
1	1-C	20000.	140.0	11825.	6366.	30.0	378.	182.	30.0	378.	182.
2	1-C	10000.	118.9	10452.	4255.	30.0	437.	206.	30.0	437.	206.
3	1-0	1500.	104.5	9436.	3841.	30.0	497.	234.	30.0	497.	234.
4	0-9	20000.	140.0	11331.	6100.	38.8	1543.	646.	53.8	1901.	729.
5	0-9	10000.	118.9	10018.	4079.	33.1	1336.	563.	46.2	1564.	640.
6	0-9	1500.	104.5	9047.	3684.	30.0	1196.	504.	40.9	1402.	574.
7	0-9	20000.	140.0	11134.	4459.	30.0	538.	254.	35.3	610.	286.
8	0-9	10000.	118.9	9841.	3976.	30.0	546.	253.	30.7	558.	259.
9	0-9	1500.	104.5	8885.	3590.	30.0	574.	266.	30.0	574.	266.
10	0-9	20000.	140.0	11104.	4414.	30.0	367.	177.	30.0	367.	177.
11	0-9	10000.	118.9	9814.	3961.	30.0	422.	199.	30.0	422.	199.
12	0-9	1500.	104.5	8860.	3576.	30.0	479.	225.	30.0	479.	225.
13	0-9	20000.	140.0	11104.	4414.	30.0	367.	177.	30.0	367.	177.
14	0-9	10000.	118.9	9814.	3961.	30.0	422.	199.	30.0	422.	199.
15	0-9	1500.	104.5	8860.	3576.	30.0	479.	225.	30.0	479.	225.
16	0-8	20000.	140.0	11333.	6101.	57.9	4100.	1605.	78.4	4626.	1739.
17	0-8	10000.	118.9	10030.	4086.	49.4	3500.	1398.	67.0	4051.	1559.
18	0-8	1500.	104.5	9065.	3693.	43.5	3091.	1235.	59.2	3579.	1377.
19	0-8	20000.	140.0	10769.	4216.	46.4	2274.	856.	63.5	2641.	983.
20	0-8	10000.	118.9	9525.	3793.	39.6	1955.	760.	54.4	2275.	862.
21	0-8	1500.	104.5	8603.	3426.	34.9	1737.	675.	48.1	2024.	767.
22	0-8	20000.	140.0	10442.	4056.	31.3	874.	397.	44.7	1034.	461.
23	0-8	10000.	118.9	9231.	3639.	30.0	783.	353.	38.6	916.	407.
24	0-8	1500.	104.5	8335.	3286.	30.0	750.	338.	34.3	835.	371.
25	0-8	20000.	140.0	10350.	4014.	30.0	356.	171.	30.0	356.	171.
26	0-8	10000.	118.9	9149.	3602.	30.0	407.	192.	30.0	407.	192.
27	0-8	1500.	104.5	8260.	3252.	30.0	460.	217.	30.0	460.	217.

11/28/67

CONVENTIONAL NON-RIGID

TABLE IV-19
DESIGN VMAX = 140. KNOTS

W0 = 625000. LBS

DESIGN ALTITUDE, H3 = 5000. FT

RECIPROCATING - COMPOUND ENGINE

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	8HP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	RHP	FUEL FLOW LBS/HR
1	1-C	5000.	140.0	23427.	15495.	30.0	553.	249.	30.0	553.	249.
2	1-0	3000.	135.9	22908.	15485.	30.0	572.	249.	30.0	572.	249.
3	1-C	1500.	132.9	22528.	14891.	30.0	587.	265.	30.0	587.	265.
4	C-9	5000.	140.0	22645.	14968.	42.8	3720.	1436.	58.1	4303.	1651.
5	C-5	3000.	135.9	22145.	14968.	41.6	3613.	1436.	56.5	4181.	1651.
6	C-5	1500.	132.9	21779.	14396.	40.7	3536.	1365.	55.3	4092.	1570.
7	C-9	5000.	140.0	21988.	14357.	30.0	531.	240.	30.0	531.	240.
8	C-9	3000.	135.9	21502.	14357.	30.0	549.	240.	30.0	549.	240.
9	C-9	1500.	132.9	21145.	13807.	30.0	563.	254.	30.0	563.	254.
10	0-9	5000.	140.0	21988.	14357.	30.0	531.	240.	30.0	531.	240.
11	C-5	3000.	135.9	21502.	14357.	30.0	549.	240.	30.0	549.	240.
12	0-9	1500.	132.9	21145.	13807.	30.0	563.	254.	30.0	563.	254.
13	C-5	5000.	140.0	21988.	14357.	30.0	531.	240.	30.0	531.	240.
14	0-5	3000.	135.9	21502.	14357.	30.0	549.	240.	30.0	549.	240.
15	C-5	1500.	132.9	21145.	13807.	30.0	563.	254.	30.0	563.	254.
16	C-8	5000.	140.0	23327.	15419.	63.8	10421.	3986.	85.9	11461.	4407.
17	0-8	3000.	135.9	22819.	15419.	62.0	10110.	3986.	83.4	11200.	4407.
18	C-8	1500.	132.9	22446.	14837.	60.7	9867.	3782.	81.7	11010.	4233.
19	C-8	5000.	140.0	20989.	13359.	40.7	3031.	1228.	55.4	3512.	1383.
20	0-8	3000.	135.9	20526.	13359.	39.5	2945.	1228.	53.8	3413.	1383.
21	C-8	1500.	132.9	20186.	12849.	38.7	2883.	1168.	52.7	3342.	1316.
22	C-8	5000.	140.0	20487.	12814.	30.0	508.	230.	30.0	508.	230.
23	0-8	3000.	135.9	20034.	12814.	30.0	525.	230.	30.0	525.	230.
24	C-8	1500.	132.9	19702.	12322.	30.0	538.	244.	30.0	538.	244.
25	C-8	5000.	140.0	20487.	12814.	30.0	508.	230.	30.0	508.	230.
26	C-8	3000.	135.9	20034.	12814.	30.0	525.	230.	30.0	525.	230.
27	0-8	1500.	132.9	19702.	12322.	30.0	538.	244.	30.0	538.	244.

11/28/67

CONVENTIONAL NON-RIGID

TABLE IV-20
DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 625000. LBS		DESIGN ALTITUDE, M3 = 10000. FT												
1	2	3	4	5	6	7	8	9	10	11	12			
LS/WC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/WC	VOLUME	WF+PL
1	1.0	W0	10000.	22454.	14046.	30.0	538.	252.	30.0	538.	252.	1.0	13326094.	256803.
2	1.0	W0	5000.	21194.	13370.	30.0	587.	264.	30.0	587.	264.	0.9	11993483.	266364.
3	1.0	W0	1500.	20362.	12846.	30.0	625.	281.	30.0	625.	281.	0.8	10650874.	274733.
4	0.9	W0	10000.	21763.	13613.	43.9	3817.	1531.	59.6	4414.	1707.			
5	0.9	W0	5000.	20546.	12963.	40.7	3542.	1389.	55.3	4799.	1568.			
6	0.9	W0	1500.	19743.	12457.	38.7	3367.	1320.	52.6	3898.	1491.			
7	0.9	W1	10000.	21071.	12794.	30.0	517.	242.	30.0	517.	242.			
8	0.9	W1	5000.	19889.	12297.	30.0	563.	254.	30.0	563.	254.			
9	0.9	W1	1500.	19109.	11815.	30.0	598.	269.	30.0	598.	269.			
10	0.9	W2	10000.	21071.	12794.	30.0	517.	242.	30.0	517.	242.			
11	0.9	W2	5000.	19889.	12297.	30.0	563.	254.	30.0	563.	254.			
12	0.9	W2	1500.	19109.	11815.	30.0	598.	269.	30.0	598.	269.			
13	0.9	W3	10000.	21071.	12794.	30.0	517.	242.	30.0	517.	242.			
14	0.9	W3	5000.	19889.	12297.	30.0	563.	254.	30.0	563.	254.			
15	0.9	W3	1500.	19109.	11815.	30.0	598.	269.	30.0	598.	269.			
16	0.8	W0	10000.	22619.	14149.	65.4	10700.	4215.	88.0	11697.	4500.			
17	0.8	W0	5000.	21370.	13490.	60.7	9903.	3817.	81.7	11027.	4222.			
18	0.8	W0	1500.	20546.	12969.	57.7	9396.	3621.	77.6	10588.	4054.			
19	0.8	W1	10000.	20236.	10334.	43.2	3425.	1417.	58.7	3964.	1591.			
20	0.8	W1	5000.	19104.	11155.	40.1	3180.	1284.	54.6	3683.	1444.			
21	0.8	W1	1500.	18358.	10719.	38.1	3025.	1221.	51.9	3504.	1373.			
22	0.8	W2	10000.	19629.	8057.	30.0	496.	233.	30.0	496.	233.			
23	0.8	W2	5000.	18527.	9660.	30.0	538.	244.	30.0	538.	244.			
24	0.8	W2	1500.	17801.	9281.	30.0	571.	258.	30.0	571.	258.			
25	0.8	W3	10000.	19629.	8057.	30.0	496.	233.	30.0	496.	233.			
26	0.8	W3	5000.	18527.	9660.	30.0	538.	244.	30.0	538.	244.			
27	0.8	W3	1500.	17801.	9281.	30.0	571.	258.	30.0	571.	258.			

TABLE IV-21
DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 20000. FT

W0 = 625000. LBS		DESIGN ALTITUDE, H3 = 20000. FT						LS/WO		VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	W0	140.0	20544.	11060.	30.0	510.	243.	30.0	510.	243.	
2	1.0	W0	118.9	18155.	7391.	30.0	612.	284.	30.0	612.	294.	
3	1.0	W0	104.5	16388.	6671.	30.0	718.	332.	30.0	718.	332.	
4	C.5	W0	140.0	20043.	10790.	46.2	4030.	1610.	62.7	4661.	1770.	
5	C.5	W0	118.9	17723.	7217.	39.4	3442.	1399.	53.6	3683.	1564.	
6	C.5	W0	104.5	16006.	6517.	34.7	3039.	1235.	47.3	3520.	1383.	
7	C.9	W1	140.0	19275.	7591.	30.0	503.	239.	30.0	503.	239.	
8	C.9	W1	118.9	17034.	6816.	30.0	595.	276.	30.0	595.	276.	
9	C.5	W1	104.5	15376.	6153.	30.0	692.	321.	30.0	692.	321.	
10	C.5	W2	140.0	19273.	7590.	30.0	491.	234.	30.0	491.	234.	
11	0.9	W2	118.9	17032.	6815.	30.0	587.	272.	30.0	587.	272.	
12	C.5	W2	104.5	15374.	6152.	30.0	685.	318.	30.0	685.	318.	
13	C.5	W3	140.0	19273.	7590.	30.0	491.	234.	30.0	491.	234.	
14	C.5	W3	118.9	17032.	6815.	30.0	587.	272.	30.0	587.	272.	
15	C.5	W3	104.5	15374.	6152.	30.0	685.	318.	30.0	685.	318.	
16	0.8	W0	140.0	21280.	11456.	68.9	11319.	4456.	92.7	12211.	4667.	
17	C.8	W0	118.9	18049.	7682.	58.7	9610.	3862.	79.1	10782.	4213.	
18	C.8	W0	104.5	17049.	6948.	51.8	8441.	3392.	69.8	9732.	3803.	
19	C.8	W1	140.0	18808.	7233.	48.5	4284.	1711.	65.7	4952.	1900.	
20	C.8	W1	118.9	16633.	6515.	41.3	3656.	1486.	56.1	4230.	1661.	
21	0.8	W1	104.5	15023.	5884.	36.4	3227.	1311.	49.6	3736.	1467.	
22	C.8	W2	140.0	17947.	6837.	30.0	476.	228.	30.0	476.	228.	
23	0.8	W2	118.9	15861.	6169.	30.0	564.	263.	30.0	564.	263.	
24	C.8	W2	104.5	14317.	5568.	30.0	655.	305.	30.0	655.	305.	
25	C.8	W3	140.0	17947.	6837.	30.0	471.	225.	30.0	471.	225.	
26	0.8	W3	118.9	15860.	6168.	30.0	560.	261.	30.0	560.	261.	
27	0.8	W3	104.5	14316.	5568.	30.0	652.	304.	30.0	652.	304.	

TABLE IV-22
DESIGN VMAX = 140. KNOTS

TABLE IV-22
DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

CONVENTIONAL NGN-RIGID

DESIGN ALTITUDE, H3 = 5000. FT

WC = 150000. LBS

DESIGN ALTITUDE, H3 = 5000. FT															
WC = 1500000. LBS			1	2	3	4	5	6	7	8	9	LS/WO	VOLUME	WF+2L	
LS/WO			H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	BHP	FUEL FLOW LBS/HR		V(MAX RGF) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	WO	5000.	140.0	39810.	26314.	30.0	801.	354.	801.	354.		30.0	801.	354.
2	1-O	WO	3000.	135.5	38928.	26314.	30.0	833.	354.	833.	354.		30.0	833.	354.
3	1-C	WO	1500.	132.9	38281.	25304.	30.0	858.	379.	858.	379.		30.0	858.	379.
4	C-5	WO	5000.	140.0	39447.	26074.	50.6	9787.	3808.	9787.	3808.		68.1	11282.	4319.
5	0-9	WO	3000.	135.5	38575.	26074.	49.1	9496.	3808.	9496.	3808.		66.1	10947.	4319.
6	C-5	WO	1500.	132.9	37943.	25080.	48.0	9286.	3613.	9286.	3613.		64.7	10705.	4098.
7	C-5	W1	5000.	140.0	37338.	24242.	30.0	763.	338.	763.	338.		30.0	763.	338.
8	0-9	W1	3000.	135.5	36510.	24242.	30.0	794.	338.	794.	338.		30.0	794.	338.
9	0-9	W1	1500.	132.9	35904.	23311.	30.0	817.	362.	817.	362.		30.0	817.	362.
10	0-9	W2	5000.	140.0	37338.	24242.	30.0	763.	338.	763.	338.		30.0	763.	338.
11	C-5	W2	3000.	135.9	36510.	24242.	30.0	794.	338.	794.	338.		30.0	794.	338.
12	0-9	W2	1500.	132.5	35904.	23311.	30.0	817.	362.	817.	362.		30.0	817.	362.
13	C-5	W3	5000.	140.0	37338.	24242.	30.0	763.	338.	763.	338.		30.0	763.	338.
14	0-9	W3	3000.	135.9	36510.	24242.	30.0	794.	338.	794.	338.		30.0	794.	338.
15	C-9	W3	1500.	132.5	35904.	23311.	30.0	817.	362.	817.	362.		30.0	817.	362.
16	0-E	WO	5000.	140.0	43884.	29008.	75.4	27578.	10965.	27578.	10965.		101.1	29468.	11775.
17	0-8	WO	3000.	135.5	42938.	29008.	73.2	26923.	10965.	26923.	10965.		98.2	28815.	11775.
18	C-E	WO	1500.	132.9	42244.	27923.	71.6	26445.	10514.	26445.	10514.		96.1	28338.	11333.
19	C-E	W1	5000.	140.0	35900.	21469.	43.9	6172.	2366.	6172.	2366.		59.3	7123.	2737.
20	0-E	W1	3000.	135.5	35107.	21469.	42.6	5991.	2366.	5991.	2366.		57.6	6915.	2737.
21	C-E	W1	1500.	132.5	34527.	20648.	41.7	5860.	2247.	5860.	2247.		56.4	6755.	2600.
22	C-E	W2	5000.	140.0	34758.	20184.	30.0	724.	322.	724.	322.		30.0	724.	322.
23	C-E	W2	3000.	135.5	33988.	20184.	30.0	753.	322.	753.	322.		30.0	753.	322.
24	C-E	W2	1500.	132.9	33424.	19409.	30.0	775.	344.	775.	344.		30.0	775.	344.
25	C-E	W3	5000.	140.0	34756.	20184.	30.0	724.	322.	724.	322.		30.0	724.	322.
26	C-E	W3	3000.	135.5	33988.	20184.	30.0	753.	322.	753.	322.		30.0	753.	322.
27	0-8	W3	1500.	132.9	33424.	19409.	30.0	775.	344.	775.	344.		30.0	775.	344.

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CONVENTIONAL NON-RIGID

TABLE IV-23
DESIGN VMAX = 140. KNOTS

DESIGN VMAX = 140. KNOTS											
CONVENTIONAL NON-RIGID			RECIPROCATING - COMPOUND ENGINE								
WC = 1500000. LBS			DESIGN ALTITUDE, H3 = 10000. FT								
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H. FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	10000.	140.0	38201.	23896.	30.0	777.	353.	30.0	777.	353.
2	1.0	5000.	129.6	36054.	22745.	30.0	860.	374.	30.0	860.	374.
3	1.0	1500.	123.0	34639.	21852.	30.0	923.	402.	30.0	923.	402.
4	0.9	10000.	140.0	38045.	23798.	51.8	10053.	3955.	69.7	11587.	4604.
5	0.9	5000.	129.6	35923.	22668.	48.0	9305.	3581.	64.7	10726.	4169.
6	0.9	1500.	123.0	34523.	21784.	45.6	8829.	3398.	61.5	10179.	3956.
7	0.9	10000.	140.0	35825.	20874.	30.0	741.	338.	30.0	741.	338.
8	0.9	5000.	129.6	33812.	20549.	30.0	819.	358.	30.0	819.	358.
9	0.9	1500.	123.0	32484.	19742.	30.0	878.	384.	30.0	878.	384.
10	0.9	10000.	140.0	35825.	20874.	30.0	741.	338.	30.0	741.	338.
11	0.9	5000.	129.6	33812.	20549.	30.0	819.	358.	30.0	819.	358.
12	0.9	1500.	123.0	32484.	19742.	30.0	878.	384.	30.0	878.	384.
13	0.9	10000.	140.0	35825.	20874.	30.0	741.	338.	30.0	741.	338.
14	0.9	5000.	129.6	33812.	20549.	30.0	819.	358.	30.0	819.	358.
15	0.9	1500.	123.0	32484.	19742.	30.0	878.	384.	30.0	878.	384.
16	0.8	10000.	140.0	42953.	26868.	77.2	28180.	10812.	103.6	30070.	11666.
17	0.8	5000.	129.6	40606.	25643.	71.6	26497.	10390.	96.1	28393.	11285.
18	0.8	1500.	123.0	39056.	24664.	68.0	25245.	9900.	91.3	27290.	10847.
19	0.8	10000.	140.0	34766.	13840.	47.0	7148.	2901.	63.4	9246.	3236.
20	0.8	5000.	129.6	32823.	13520.	43.6	6620.	2543.	58.8	7639.	2933.
21	0.8	1500.	123.0	31541.	12992.	41.4	6285.	2414.	55.9	7253.	2785.
22	0.8	10000.	140.0	33345.	13122.	30.0	703.	323.	30.0	703.	323.
23	0.8	5000.	129.6	31472.	12699.	30.0	776.	341.	30.0	776.	341.
24	0.8	1500.	123.0	30237.	12200.	30.0	831.	365.	30.0	831.	365.
25	0.8	10000.	140.0	33345.	13122.	30.0	703.	323.	30.0	703.	323.
26	0.8	5000.	129.6	31472.	12699.	30.0	776.	341.	30.0	776.	341.
27	0.8	1500.	123.0	30237.	12200.	30.0	831.	365.	30.0	831.	365.

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CONVENTIONAL NON-RIGID

TABLE IV-24
DESIGN VMAX = 140. KNOTS

W0 = 1500000. LBS

DESIGN ALTITUDE, M3 = 20000. FT

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, M3 = 20000. FT														
W0 = 1500000. LBS			1	2	3	4	5	6	7	8	9	10	11	12
LS/W0			H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL LBS/HR	V(MAX RGE) KNOTS	RHP	FUEL FLOW LBS/HR	WF+PL	
1	1-C	W0	20000.	140.0	35025.	18856.	30.0	729.	341.	30.0	729.	341.	656776.	
2	1-C	W0	10000.	118.9	30949.	12598.	30.0	904.	408.	30.0	904.	408.	675958.	
3	1-C	W0	1500.	104.5	27934.	11371.	30.0	1083.	489.	30.0	1083.	489.	682033.	
4	0.9	W0	20000.	140.0	35314.	19012.	54.5	10640.	4296.	73.3	12142.	4735.		
5	0.9	W0	10000.	118.9	31240.	12723.	46.5	9035.	3521.	62.6	10416.	4143.		
6	0.9	W0	1500.	104.5	28221.	11494.	41.0	7937.	3093.	55.2	9154.	3641.		
7	0.9	W1	20000.	140.0	32839.	12775.	30.0	696.	327.	30.0	696.	327.		
8	0.9	W1	10000.	118.9	29018.	11455.	30.0	860.	390.	30.0	860.	390.		
9	0.9	W1	1500.	104.5	26192.	10339.	30.0	1028.	466.	30.0	1028.	466.		
10	0.9	W2	20000.	140.0	32839.	12775.	30.0	696.	327.	30.0	696.	327.		
11	0.9	W2	10000.	118.9	29018.	11455.	30.0	860.	390.	30.0	860.	390.		
12	0.9	W2	1500.	104.5	26192.	10339.	30.0	1028.	466.	30.0	1028.	466.		
13	0.9	W3	20000.	140.0	32839.	12775.	30.0	696.	327.	30.0	696.	327.		
14	0.9	W3	10000.	118.9	29018.	11455.	30.0	860.	390.	30.0	860.	390.		
15	0.9	W3	1500.	104.5	26192.	10339.	30.0	1028.	466.	30.0	1028.	466.		
16	0.8	W0	20000.	140.0	41269.	22217.	81.2	29491.	10987.	109.0	31378.	11800.		
17	0.8	W0	10000.	118.9	36614.	14931.	69.3	25841.	9841.	93.0	27807.	10641.		
18	0.8	W0	1500.	104.5	33156.	13521.	61.1	22655.	8628.	82.0	23165.	9632.		
19	0.8	W1	20000.	140.0	32555.	12311.	52.5	8936.	3501.	70.7	10281.	4117.		
20	0.8	W1	10000.	118.9	28794.	11109.	44.8	7592.	3038.	60.4	8757.	3380.		
21	0.8	W1	1500.	104.5	26010.	10034.	39.5	6674.	2671.	53.3	7701.	2972.		
22	0.8	W2	20000.	140.0	30559.	11445.	30.0	661.	310.	30.0	661.	310.		
23	0.8	W2	10000.	118.9	27004.	10306.	30.0	814.	369.	30.0	814.	369.		
24	0.8	W2	1500.	104.5	24373.	9302.	30.0	970.	440.	30.0	970.	440.		
25	0.8	W3	20000.	140.0	30559.	11445.	30.0	661.	310.	30.0	661.	310.		
26	0.8	W3	10000.	118.9	27004.	10306.	30.0	814.	369.	30.0	814.	369.		
27	0.8	W3	1500.	104.5	24373.	9302.	30.0	970.	440.	30.0	970.	440.		

CONVENTIONAL NON-RIGID

TABLE IV-25
DESIGN V_{MAX} = 210. KNJS

RECIPROCATING - COMPULSIVE ENGINE

WC = 625000. LOS			DESIGN ALTITUDE, H3 = 5000. FT					LS/WO			VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RCF) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1-C	5000.	210.0	74416.	45189.	30.0	553.	250.	30.0	553.	250.		
2	1-C	3000.	203.0	72306.	45189.	30.0	572.	250.	30.0	572.	250.		
3	1-C	1500.	199.3	70270.	45449.	30.0	587.	266.	30.0	587.	266.		
4	C-S	5000.	210.0	70290.	45462.	42.8	3720.	1447.	58.1	4303.	1647.		
5	0-9	3000.	203.8	68116.	45462.	41.6	3613.	1447.	55.5	4181.	1647.		
6	C-S	1500.	199.3	66377.	43375.	40.7	3536.	1376.	55.3	4097.	1567.		
7	C-S	5000.	210.0	69988.	46174.	31.6	1677.	637.	43.5	1955.	752.		
8	C-S	3000.	203.6	67723.	46178.	30.7	1632.	667.	42.4	1903.	752.		
9	C-S	1500.	199.3	66090.	43607.	30.0	1600.	636.	41.5	1866.	713.		
10	C-S	5000.	210.0	69858.	46057.	30.0	578.	260.	30.0	578.	260.		
11	C-S	3000.	203.8	67597.	46057.	30.0	593.	260.	30.0	593.	260.		
12	C-S	1500.	199.3	65967.	43492.	30.0	605.	272.	30.0	605.	272.		
13	C-S	5000.	210.0	69853.	46052.	30.0	531.	240.	30.0	531.	247.		
14	C-S	3000.	203.8	67591.	46052.	30.0	549.	240.	30.0	549.	240.		
15	C-S	1500.	199.3	65962.	43487.	30.0	563.	255.	30.0	563.	255.		
16	C-S	5000.	210.0	69984.	46277.	63.8	10421.	3983.	85.9	11461.	4453.		
17	C-S	3000.	203.8	64821.	46277.	62.0	10110.	3983.	83.4	11200.	4453.		
18	C-S	1500.	199.3	63263.	41817.	60.7	9887.	3779.	81.7	11010.	4278.		
19	C-S	5000.	210.0	66083.	43434.	54.0	6533.	2501.	72.8	7475.	2919.		
20	C-S	3000.	203.8	63447.	43434.	52.4	6341.	2501.	70.7	7301.	2919.		
21	C-S	1500.	199.3	62507.	41018.	51.3	6202.	2374.	69.2	7157.	2795.		
22	C-S	5000.	210.0	65470.	42865.	42.0	3308.	1325.	57.2	3830.	1487.		
23	C-S	3000.	203.8	63352.	42865.	40.8	3214.	1325.	55.5	3721.	1487.		
24	C-S	1500.	199.3	61826.	40479.	40.0	3146.	1260.	54.4	3643.	1415.		
25	C-S	5000.	210.0	65147.	42565.	30.0	981.	424.	36.3	1121.	477.		
26	C-S	3000.	203.8	63038.	42565.	30.0	970.	424.	35.3	1095.	477.		
27	C-S	1500.	199.3	61519.	40195.	30.0	964.	416.	34.6	1076.	458.		

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CONVENTIONAL NON-RIGID

TABLE IV-26
DESIGN VMAX = 210. KNOTS

RECIPROCATING - COMPOUND ENGINE

W0 = 625000. LBS DESIGN ALTITUDE, H3 = 10000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	10000.	210-C	71315.	44609.	30.0	538.	252.	30.0	538.	252.
2	1-C	5000.	194.4	65546.	40870.	30.0	587.	264.	30.0	587.	264.
3	1-C	1500.	184.5	61895.	38404.	30.0	625.	281.	30.0	625.	281.
4	C-5	10000.	210-C	67390.	42154.	43.9	3817.	1542.	59.6	4414.	1722.
5	C-5	5000.	194.4	61942.	38435.	40.7	3542.	1398.	55.3	4099.	1566.
6	0-9	1500.	184.5	58494.	36296.	38.7	3367.	1329.	52.6	3898.	1489.
7	0-9	10000.	210.0	67109.	41896.	34.4	2003.	801.	47.3	2330.	896.
8	C-5	5000.	194.4	61682.	38174.	31.9	1866.	728.	43.9	2173.	832.
9	C-5	1500.	184.5	58247.	36048.	30.3	1779.	694.	41.8	2073.	793.
10	C-5	10000.	210.0	66958.	41757.	30.0	762.	349.	31.4	795.	362.
11	0-9	5000.	194.4	61542.	38034.	30.0	773.	341.	30.0	773.	341.
12	C-5	1500.	184.5	58114.	35916.	30.0	787.	347.	30.0	787.	347.
13	C-5	10000.	210.0	66929.	41730.	30.0	517.	243.	30.0	517.	243.
14	0-9	5000.	194.4	61516.	38007.	30.0	563.	254.	30.0	563.	254.
15	C-5	1500.	184.5	53089.	35890.	30.0	598.	270.	30.0	598.	270.
16	C-8	10000.	210.0	64346.	40250.	65.4	1070.	4232.	88.0	11697.	4728.
17	0-8	5000.	194.4	59135.	36710.	60.7	9903.	3932.	81.7	11027.	4220.
18	C-8	1500.	184.5	55870.	34671.	57.7	9396.	3635.	77.6	10589.	4052.
19	C-8	10000.	210.0	63485.	39464.	56.5	7128.	2742.	76.3	8077.	3237.
20	0-8	5000.	194.4	58362.	35516.	52.4	6601.	2526.	72.8	7603.	2969.
21	C-8	1500.	184.5	55117.	33919.	49.8	6267.	2398.	67.3	7232.	2925.
22	C-8	10000.	210.0	62872.	38640.	46.1	4077.	1631.	62.5	4714.	1818.
23	C-8	5000.	194.4	57790.	35349.	42.8	3783.	1479.	58.0	4375.	1674.
24	C-8	1500.	184.5	54574.	33382.	40.7	3595.	1406.	55.2	4100.	1592.
25	C-8	10000.	210.0	62493.	38099.	32.8	1672.	697.	45.4	1950.	788.
26	C-8	5000.	194.4	57440.	35004.	30.5	1560.	634.	42.2	1821.	718.
27	0-8	1500.	184.5	54242.	33055.	30.0	1492.	606.	40.2	1739.	686.

11/28/67

CONVENTIONAL NON-RIGID

TABLE IV-27
DESIGN VMAX = 210. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 625000. LBS

	1	2	3	4	5	6	7	8	9	10	11	12
	LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	20000.	210.0	65232.	35118.	30.0	510.	243.	30.0	510.	243.
2	1.0	W0	10000.	178.4	54581.	21692.	30.0	612.	285.	30.0	612.	285.
3	1.0	W0	1500.	156.8	47368.	18826.	30.0	718.	333.	30.0	719.	333.
4	0.5	W0	20000.	210.0	61713.	33223.	46.2	4030.	1647.	62.7	4661.	1838.
5	0.5	W0	10000.	178.4	51643.	25226.	39.4	3442.	1426.	53.6	3983.	1671.
6	0.5	W0	1500.	156.8	44825.	17816.	34.7	3039.	1259.	47.3	3520.	1415.
7	0.5	W1	20000.	210.0	61424.	30791.	37.3	2279.	904.	51.1	2647.	907.
8	0.5	W1	10000.	178.4	51398.	20386.	31.8	1960.	790.	43.7	2280.	886.
9	0.5	W1	1500.	156.8	44605.	17693.	30.0	1751.	706.	38.7	2028.	788.
10	0.5	W2	20000.	210.0	61253.	29358.	30.0	948.	434.	36.6	1088.	491.
11	0.5	W2	10000.	178.4	51253.	20304.	30.0	917.	414.	31.6	962.	432.
12	0.5	W2	1500.	156.8	44481.	17621.	30.0	940.	424.	30.0	940.	422.
13	0.5	W3	20000.	210.0	61199.	28909.	30.0	491.	235.	30.0	491.	235.
14	0.5	W3	10000.	178.4	51207.	20278.	30.0	587.	274.	30.0	587.	274.
15	0.5	W3	1500.	156.8	44441.	17598.	30.0	685.	320.	30.0	685.	320.
16	0.8	W0	20000.	210.0	59213.	31878.	68.9	11319.	4448.	92.7	12211.	4652.
17	0.8	W0	10000.	178.4	49575.	19708.	58.7	9610.	3856.	79.1	10782.	4206.
18	0.8	W0	1500.	156.8	43046.	17112.	51.8	8441.	3387.	69.8	9732.	3797.
19	0.8	W1	20000.	210.0	58336.	24552.	60.4	7867.	3203.	81.5	8772.	3477.
20	0.8	W1	10000.	178.4	48830.	19286.	51.6	6688.	2586.	69.5	7717.	3094.
21	0.8	W1	1500.	156.8	42391.	16743.	45.4	5882.	2274.	61.4	6789.	2722.
22	0.8	W2	20000.	210.0	57678.	22860.	50.8	4861.	1857.	68.7	5616.	2312.
23	0.8	W2	10000.	178.4	48271.	19031.	43.3	4145.	1633.	58.7	4791.	1822.
24	0.8	W2	1500.	156.8	41900.	16519.	38.2	3655.	1440.	51.8	4228.	1608.
25	0.8	W3	20000.	210.0	57239.	22600.	38.9	2391.	920.	53.3	2775.	1037.
26	0.8	W3	10000.	178.4	47898.	18361.	33.2	2054.	811.	45.6	2383.	909.
27	0.8	W3	1500.	156.8	41572.	16370.	30.0	1825.	721.	40.3	2123.	808.

11/28/67

TABLE IV-28
DESIGN VMAX = 70. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE									
AC = 100000. LBS		DESIGN ALTITUDE, H3 = 5000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WF+PL	
1	1-C	MO	5000.	1188.	785.	30.0	305.	118.	30.2	307.	118.	29487.	
2	1-C	MO	3000.	1149.	760.	30.0	311.	120.	30.0	311.	127.	30871.	
3	1-C	MO	1500.	1122.	742.	30.0	315.	121.	30.0	315.	122.	31769.	
4	C-5	MO	5000.	1249.	826.	30.7	608.	233.	45.5	730.	286.		
5	C-9	MO	3000.	1210.	800.	30.0	595.	229.	44.3	716.	281.		
6	C-5	MO	1500.	1181.	781.	30.0	587.	225.	43.5	706.	277.		
7	C-5	W1	5000.	1124.	715.	30.0	315.	121.	32.4	338.	131.		
8	C-9	W1	3000.	1088.	692.	30.0	319.	123.	31.8	337.	137.		
9	C-5	W1	1500.	1062.	676.	30.0	323.	124.	31.3	336.	130.		
10	C-5	W2	5000.	1117.	707.	30.0	299.	115.	30.9	307.	113.		
11	C-9	W2	3000.	1081.	684.	30.0	304.	117.	30.3	307.	118.		
12	C-5	W2	1500.	1055.	668.	30.0	308.	118.	30.0	308.	119.		
13	C-5	W3	5000.	1081.	707.	30.0	299.	115.	30.9	307.	118.		
14	C-5	W3	3000.	1081.	684.	30.0	304.	117.	30.3	307.	118.		
15	C-9	W3	1500.	1055.	668.	30.0	308.	118.	30.0	308.	119.		
16	C-8	W0	5000.	1616.	1068.	45.7	1386.	854.	63.4	1619.	1070.		
17	C-3	W0	3000.	1566.	1035.	44.3	1350.	832.	61.6	1578.	1043.		
18	C-8	W0	1500.	1529.	1011.	43.4	1324.	816.	60.4	1548.	1024.		
19	C-8	W1	5000.	1251.	661.	35.1	760.	291.	50.8	903.	351.		
20	C-8	W1	3000.	1212.	640.	34.1	743.	285.	49.4	884.	343.		
21	C-8	W1	1500.	1183.	625.	33.4	731.	280.	48.4	870.	338.		
22	C-8	W2	5000.	1067.	426.	30.0	349.	133.	36.2	405.	156.		
23	C-8	W2	3000.	1033.	412.	30.0	351.	134.	35.4	401.	154.		
24	C-8	W2	1500.	1008.	402.	30.0	352.	135.	34.8	399.	153.		
25	C-8	W3	5000.	1043.	415.	30.0	292.	116.	31.6	307.	121.		
26	C-8	W3	3000.	1010.	402.	30.0	297.	118.	31.1	307.	121.		
27	C-8	W3	1500.	985.	392.	30.0	301.	120.	30.6	307.	121.		

11/26/67

TABLE IV-29
DESIGN VMAX = 70. KNOTS

CONVENTIONAL			RIGID	DESIGN ALTITUDE, H3 = 10000. FT			RECIPROCATING - COMPOUND ENGINE				
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO	W0	H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	WF+PL
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		FUEL
											LBS/HR
1	1-C	10000.	70.0	1134.	709.	30.0	300.	115.	30.7	307.	27536.
2	1-C	5000.	64.8	1042.	647.	30.0	315.	121.	30.0	315.	29075.
3	1-0	1500.	61.5	985.	611.	30.0	326.	126.	30.0	326.	29986.
4	C-5	10000.	70.0	1205.	754.	31.5	618.	238.	46.6	742.	283.
5	C-5	5000.	64.8	1109.	689.	30.0	587.	225.	43.5	706.	274.
6	C-5	1500.	61.5	1048.	651.	30.0	570.	218.	41.6	683.	265.
7	C-9	10000.	70.0	1076.	542.	30.0	319.	122.	33.6	352.	134.
8	C-9	5000.	64.8	990.	525.	30.0	329.	127.	31.9	348.	135.
9	C-9	1500.	61.5	935.	496.	30.0	337.	130.	30.7	345.	134.
10	C-9	10000.	70.0	1066.	499.	30.0	294.	115.	31.4	307.	119.
11	C-5	5000.	64.8	980.	487.	30.0	308.	118.	30.0	308.	118.
12	C-9	1500.	61.5	926.	460.	30.0	319.	122.	30.0	319.	122.
13	C-5	10000.	70.0	1066.	499.	30.0	294.	115.	31.4	307.	119.
14	C-9	5000.	64.8	980.	487.	30.0	308.	118.	30.0	308.	118.
15	C-9	1500.	61.5	926.	460.	30.0	319.	122.	30.0	319.	122.
16	0-8	10000.	70.0	1598.	1000.	46.8	1417.	676.	65.0	1655.	1048.
17	C-8	5000.	64.8	1473.	916.	43.4	1324.	744.	60.5	1549.	998.
18	0-8	1500.	61.5	1394.	867.	41.3	1266.	711.	57.6	1482.	955.
19	0-8	10000.	70.0	1231.	484.	36.7	806.	312.	52.8	956.	364.
20	C-8	5000.	64.8	1133.	453.	34.1	760.	291.	49.2	904.	349.
21	0-8	1500.	61.5	1071.	428.	33.4	731.	280.	46.9	870.	336.
22	0-8	10000.	70.0	1033.	395.	30.0	376.	148.	38.6	450.	170.
23	C-8	5000.	64.8	950.	369.	30.0	377.	144.	36.3	437.	168.
24	C-8	1500.	61.5	897.	349.	30.0	379.	145.	34.9	429.	165.
25	C-8	10000.	70.0	995.	379.	30.0	288.	120.	32.2	307.	127.
26	0-8	5000.	64.8	915.	354.	30.0	301.	120.	30.7	307.	122.
27	C-8	1500.	61.5	864.	334.	30.0	311.	124.	30.0	311.	123.

11/28/67

TABLE IV-30
DESIGN VMAX = 70. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE									
WG = 100000. LBS		WG = 100000. LBS		DESIGN ALTITUDE, H3 = 20000. FT									
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	VMIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	VMAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/WO	WF+PL
1	1.0	W0	20000.	1029.	554.	30.0	291.	112.	31.8	303.	116.	1.0	19342.
2	1.0	W0	10000.	862.	343.	30.0	322.	123.	30.0	322.	123.	0.9	21041.
3	1.0	W0	1500.	749.	298.	30.0	353.	134.	30.0	353.	134.	0.8	21914.
4	0.5	W0	20000.	1122.	604.	33.2	642.	246.	48.9	769.	286.		
5	0.5	W0	10000.	942.	375.	30.0	576.	224.	42.4	692.	263.		
6	0.5	W0	1500.	820.	326.	30.0	546.	213.	37.8	640.	243.		
7	0.5	W1	20000.	1302.	386.	30.0	367.	137.	38.6	439.	166.		
8	0.5	W1	10000.	840.	327.	30.0	373.	143.	34.0	415.	161.		
9	0.5	W1	1500.	730.	284.	30.0	389.	149.	30.8	399.	155.		
10	0.5	W2	20000.	967.	369.	30.0	286.	114.	32.5	307.	120.		
11	0.5	W2	10000.	810.	314.	30.0	314.	120.	30.0	314.	120.		
12	0.5	W2	1500.	703.	273.	30.0	344.	131.	30.0	344.	131.		
13	0.5	W3	20000.	967.	369.	30.0	286.	114.	32.5	307.	120.		
14	0.5	W3	10000.	810.	314.	30.0	314.	120.	30.0	314.	120.		
15	0.5	W3	1500.	703.	273.	30.0	344.	131.	30.0	344.	131.		
16	0.8	W0	20000.	1574.	848.	49.4	1486.	580.	68.5	1734.	1089.		
17	0.8	W0	10000.	1327.	529.	42.1	1288.	508.	58.7	1508.	865.		
18	0.8	W0	1500.	1158.	462.	37.1	1153.	455.	52.0	1353.	776.		
19	0.8	W1	20000.	1256.	476.	41.9	1000.	375.	59.2	1177.	442.		
20	0.8	W1	10000.	1057.	404.	35.7	877.	334.	51.0	1037.	396.		
21	0.8	W1	1500.	921.	352.	31.5	793.	302.	45.3	941.	359.		
22	0.8	W2	20000.	1039.	388.	32.8	597.	224.	48.7	717.	293.		
23	0.8	W2	10000.	872.	333.	30.0	538.	207.	42.3	649.	266.		
24	0.8	W2	1500.	759.	290.	30.0	513.	197.	37.8	602.	247.		
25	0.8	W3	20000.	923.	349.	30.0	330.	137.	37.4	390.	157.		
26	0.8	W3	10000.	774.	305.	30.0	343.	139.	33.2	375.	149.		
27	0.8	W3	1500.	672.	265.	30.0	362.	147.	30.2	365.	145.		

11/28/67

TABLE IV-31
DESIGN VMAX = 70. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE											
WG = 25000G. LBS		DESIGN ALTITUDE, H3 = 5000. FT													
1	2	3	4	5	6	7	8	9	10	11	12				
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR				
1	1-C	5000.	70.0	2043.	1350.	30.0	381.	150.	30.0	381.	150.				
2	1-C	3000.	67.9	1977.	1307.	30.0	391.	154.	30.0	391.	154.				
3	1-C	1500.	66.4	1929.	1275.	30.0	399.	157.	30.0	399.	157.				
4	C-5	5000.	70.0	2367.	1565.	36.6	1360.	531.	50.9	1590.	635.				
5	0-9	3000.	67.9	2292.	1515.	35.6	1325.	518.	49.5	1550.	619.				
6	0-9	1500.	66.4	2238.	1479.	34.8	1299.	508.	48.5	1520.	608.				
7	C-5	5000.	70.0	1918.	1137.	30.0	370.	151.	30.0	370.	151.				
8	0-9	3000.	67.9	1856.	1100.	30.0	379.	155.	30.0	379.	155.				
9	0-9	1500.	66.4	1812.	1074.	30.0	387.	158.	30.0	387.	158.				
10	C-5	5000.	70.0	1918.	1137.	30.0	370.	151.	30.0	370.	151.				
11	C-5	3000.	67.9	1856.	1100.	30.0	379.	155.	30.0	379.	155.				
12	0-9	1500.	66.4	1812.	1074.	30.0	387.	158.	30.0	387.	158.				
13	C-5	5000.	70.0	1918.	1137.	30.0	370.	151.	30.0	370.	151.				
14	0-9	3000.	67.9	1856.	1100.	30.0	379.	155.	30.0	379.	155.				
15	C-5	1500.	66.4	1812.	1074.	30.0	387.	158.	30.0	387.	158.				
16	C-8	5000.	70.0	3733.	2467.	54.5	3572.	2323.	73.9	1134.	450.				
17	C-8	3000.	67.9	3617.	2391.	52.9	3469.	2256.	71.8	1108.	440.				
18	C-8	1500.	66.4	3534.	2336.	51.8	3396.	2208.	70.3	1088.	432.				
19	C-8	5000.	70.0	2049.	794.	32.4	962.	371.	45.9	358.	156.				
20	C-8	3000.	67.9	1984.	769.	31.5	939.	362.	44.7	367.	160.				
21	0-8	1500.	66.4	1937.	750.	30.8	922.	355.	43.8	374.	162.				
22	C-8	5000.	70.0	1788.	686.	30.0	358.	156.	30.0	358.	156.				
23	C-8	3000.	67.9	1730.	664.	30.0	367.	160.	30.0	367.	160.				
24	0-8	1500.	66.4	1689.	648.	30.0	374.	162.	30.0	374.	162.				
25	C-8	5000.	70.0	1788.	686.	30.0	358.	156.	30.0	358.	156.				
26	0-8	3000.	67.9	1730.	664.	30.0	367.	160.	30.0	367.	160.				
27	0-8	1500.	66.4	1689.	648.	30.0	374.	162.	30.0	374.	162.				

11/28/67

TABLE IV-32
DESIGN VMAX = 70. KNOTS

CONVENTIONAL		RIGID		DESIGN ALTITUDE, H3 = 10000. FT				RECIPROCATING - COMPOUND ENGINE			
W0 = 250000. LBS											
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX AGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	10000.	70.0	1955.	1223.	30.0	373.	154.	30.0	373.	154.
2	1.0	5000.	64.8	1797.	1115.	30.0	399.	156.	30.0	399.	156.
3	1.0	1500.	61.5	1698.	1054.	30.0	418.	164.	30.0	418.	164.
4	0.5	10000.	70.0	2308.	1444.	37.5	1391.	530.	52.2	1626.	631.
5	0.9	5000.	64.8	2125.	1320.	34.8	1301.	502.	48.5	1522.	605.
6	0.5	1500.	61.5	2009.	1248.	33.1	1243.	480.	46.2	1456.	579.
7	0.5	10000.	70.0	1835.	725.	30.0	363.	155.	30.0	363.	155.
8	0.9	5000.	64.8	1687.	680.	30.0	387.	157.	30.0	387.	157.
9	0.5	1500.	61.5	1594.	642.	30.0	405.	165.	30.0	405.	165.
10	0.9	10000.	70.0	1835.	725.	30.0	363.	155.	30.0	363.	155.
11	0.5	5000.	64.8	1687.	680.	30.0	387.	157.	30.0	387.	157.
12	0.5	1500.	61.5	1594.	642.	30.0	405.	165.	30.0	405.	165.
13	0.9	10000.	70.0	1835.	725.	30.0	363.	155.	30.0	363.	155.
14	0.5	5000.	64.8	1687.	680.	30.0	387.	157.	30.0	387.	157.
15	0.5	1500.	61.5	1594.	642.	30.0	405.	165.	30.0	405.	165.
16	0.8	10000.	70.0	3757.	2350.	55.9	3662.	2244.	75.8	1273.	492.
17	0.8	5000.	64.8	3468.	2157.	51.8	3400.	2089.	70.3	1196.	473.
18	0.8	1500.	61.5	3284.	2043.	49.2	3233.	1987.	66.9	1147.	454.
19	0.8	10000.	70.0	2034.	775.	34.6	1083.	410.	48.8	1273.	492.
20	0.8	5000.	64.8	1872.	718.	32.1	1016.	392.	45.4	1196.	473.
21	0.8	1500.	61.5	1770.	678.	30.5	974.	375.	43.3	1147.	454.
22	0.8	10000.	70.0	1710.	680.	30.0	352.	160.	30.0	352.	160.
23	0.8	5000.	64.8	1572.	613.	30.0	374.	163.	30.0	374.	163.
24	0.8	1500.	61.5	1485.	579.	30.0	391.	170.	30.0	391.	170.
25	0.8	10000.	70.0	1710.	680.	30.0	352.	160.	30.0	352.	160.
26	0.8	5000.	64.8	1572.	613.	30.0	374.	163.	30.0	374.	163.
27	0.8	1500.	61.5	1485.	579.	30.0	391.	170.	30.0	391.	170.

11/28/67

TABLE IV-33
DESIGN VMAX = 70. KNOTS

CONVENTIONAL			RIGID		DESIGN ALTITUDE, H3 = 20000. FT				RECIPROCATING - COMPOUND ENGINE				
W0 = 250000. LBS													
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO	H	FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/WO	WF+PL
1 1-C	W0	20000.	70.0	1782.	960.	30.0	358.	150.	30.0	358.	150.	1.0	7897678.
2 1.0	W0	10000.	59.5	1493.	593.	30.0	411.	164.	30.0	411.	164.	0.9	7107908.
3 1.0	W0	1500.	52.3	1296.	515.	30.0	465.	186.	30.0	465.	186.	0.8	6318140.
4 C-9	W0	20000.	70.0	2200.	1184.	39.5	1461.	545.	54.8	1705.	643.		
5 0.9	W0	10000.	59.5	1849.	736.	33.7	1267.	481.	47.1	1484.	568.		
6 C-9	W0	1500.	52.3	1610.	641.	30.0	1135.	431.	41.7	1332.	510.		
7 C-9	W1	20000.	70.0	1673.	629.	30.0	348.	152.	30.0	348.	152.		
8 0.9	W1	10000.	59.5	1401.	534.	30.0	398.	167.	30.0	398.	167.		
9 0.9	W1	1500.	52.3	1217.	464.	30.0	449.	189.	30.0	449.	189.		
10 C-9	W2	20000.	70.0	1673.	629.	30.0	348.	152.	30.0	348.	152.		
11 0.9	W2	10000.	59.5	1401.	534.	30.0	398.	167.	30.0	398.	167.		
12 0.9	W2	1500.	52.3	1217.	464.	30.0	449.	189.	30.0	449.	189.		
13 0.9	W3	20000.	70.0	1673.	629.	30.0	348.	152.	30.0	348.	152.		
14 0.9	W3	10000.	59.5	1401.	534.	30.0	398.	167.	30.0	398.	167.		
15 C-9	W3	1500.	52.3	1217.	464.	30.0	449.	189.	30.0	449.	189.		
16 0.8	W0	20000.	70.0	3840.	2067.	58.9	3863.	2192.	79.8				
17 C-8	W0	10000.	59.5	3244.	1295.	50.2	3301.	1328.	68.2				
18 0.8	W0	1500.	52.3	2837.	1132.	44.2	2916.	1173.	60.2				
19 C-8	W1	20000.	70.0	2109.	823.	40.7	1478.	557.	56.5	1725.	708.		
20 0.8	W1	10000.	59.5	1773.	709.	34.7	1282.	490.	48.4	1571.	589.		
21 0.8	W1	1500.	52.3	1544.	618.	30.6	1148.	438.	42.9	1347.	527.		
22 C-8	W2	20000.	70.0	1558.	653.	30.0	338.	157.	30.0	338.	157.		
23 0.8	W2	10000.	59.5	1305.	500.	30.0	384.	174.	30.0	384.	174.		
24 C-8	W2	1500.	52.3	1133.	435.	30.0	432.	196.	30.0	432.	196.		
25 C-8	W3	20000.	70.0	1558.	653.	30.0	338.	157.	30.0	338.	157.		
26 0.8	W3	10000.	59.5	1305.	500.	30.0	384.	174.	30.0	384.	174.		
27 C-8	W3	1500.	52.3	1133.	435.	30.0	432.	196.	30.0	432.	196.		

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TABLE IV-34
DESIGN VMAX = 70. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE									
W0 = 25000. LBS		DESIGN ALTITUDE, H3 = 5000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	VMAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WF+PL	
1	1.0	5000.	70.0	3549.	2346.	30.0	515.	213.	30.0	515.	213.	376937.	
2	1.0	3000.	67.9	3435.	2270.	30.0	532.	220.	30.0	532.	220.	373111.	
3	1.0	1500.	66.4	3352.	2216.	30.0	546.	225.	30.0	546.	225.	362133.	
4	0.9	5000.	70.0	4855.	3209.	43.5	3509.	1447.	50.1	4053.	2462.		
5	0.9	3000.	67.9	4702.	3108.	42.3	3404.	1406.	57.4	3943.	2392.		
6	0.9	1500.	66.4	4592.	3035.	41.4	3336.	1376.	56.2	3860.	2342.		
7	0.9	5000.	70.0	3330.	1338.	30.0	496.	214.	30.0	496.	214.		
8	0.9	3000.	67.9	3222.	1295.	30.0	512.	221.	30.0	512.	221.		
9	0.9	1500.	66.4	3145.	1264.	30.0	524.	226.	30.0	524.	226.		
10	0.9	5000.	70.0	3330.	1338.	30.0	496.	214.	30.0	496.	214.		
11	0.9	3000.	67.9	3222.	1295.	30.0	512.	221.	30.0	512.	221.		
12	0.9	1500.	66.4	3145.	1264.	30.0	524.	226.	30.0	524.	226.		
13	0.9	5000.	70.0	3330.	1338.	30.0	496.	214.	30.0	496.	214.		
14	0.9	3000.	67.9	3222.	1295.	30.0	512.	221.	30.0	512.	221.		
15	0.9	1500.	66.4	3145.	1264.	30.0	524.	226.	30.0	524.	226.		
16	0.8	5000.	70.0	9699.	6411.	64.8	9815.	6511.	87.2	496.	214.		
17	0.8	3000.	67.9	9403.	6216.	63.0	9523.	6318.	84.7	496.	214.		
18	0.8	1500.	66.4	9190.	6075.	61.6	9313.	6178.	82.9	496.	214.		
19	0.8	5000.	70.0	3602.	1422.	33.3	1626.	655.	45.9	1895.	740.		
20	0.8	3000.	67.9	3487.	1377.	32.3	1582.	637.	44.7	1845.	721.		
21	0.8	1500.	66.4	3404.	1344.	31.6	1551.	625.	43.7	1809.	707.		
22	0.8	5000.	70.0	3100.	1234.	30.0	475.	217.	30.0	475.	217.		
23	0.8	3000.	67.9	3000.	1194.	30.0	490.	223.	30.0	490.	223.		
24	0.8	1500.	66.4	2928.	1165.	30.0	502.	229.	30.0	502.	229.		
25	0.8	5000.	70.0	3100.	1234.	30.0	475.	217.	30.0	475.	217.		
26	0.8	3000.	67.9	3000.	1194.	30.0	490.	223.	30.0	490.	223.		
27	0.8	1500.	66.4	2928.	1165.	30.0	502.	229.	30.0	502.	229.		

RECIPROCATING - COMPOUND ENGINE

TABLE IV-35
DESIGN VMAX = 70. KNOTS

MC = 625000. LBS			DESIGN ALTITUDE, H3 = 10000. FT						LS/WO		VOLUME		WF+PL	
			1	2	3	4	5	6	7	8	9	10	11	12
	LS/MC	H FT.				VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	MC	10000.			70.0	3401.	2128.	30.0	502.	217.	30.0	502.	217.
2	1.0	MC	5000.			64.8	3127.	1941.	30.0	546.	224.	30.0	546.	224.
3	1.0	MC	1500.			61.5	2954.	1833.	30.0	580.	238.	30.0	580.	238.
4	C.5	MC	10000.			70.0	4796.	3000.	44.6	3600.	1409.	60.5	4163.	1719.
5	C.9	MC	5000.			64.8	4420.	2747.	41.4	3342.	1333.	56.2	3867.	1807.
6	C.5	MC	1500.			61.5	4181.	2599.	39.3	3178.	1267.	53.4	3678.	1719.
7	C.5	W1	10000.			70.0	3190.	1228.	30.0	483.	218.	30.0	483.	218.
8	C.9	W1	5000.			64.8	2933.	1147.	30.0	525.	226.	30.0	525.	226.
9	C.5	W1	1500.			61.5	2771.	1084.	30.0	556.	240.	30.0	556.	240.
10	C.5	W2	10000.			70.0	3190.	1228.	30.0	483.	218.	30.0	483.	218.
11	C.5	W2	5000.			64.8	2933.	1147.	30.0	525.	226.	30.0	525.	226.
12	C.9	W2	1500.			61.5	2771.	1084.	30.0	556.	240.	30.0	556.	240.
13	C.9	W3	10000.			70.0	3190.	1228.	30.0	483.	218.	30.0	483.	218.
14	C.5	W3	5000.			64.8	2933.	1147.	30.0	525.	226.	30.0	525.	226.
15	C.9	W3	1500.			61.5	2771.	1084.	30.0	556.	240.	30.0	556.	240.
16	C.8	MC	10000.			70.0	9917.	6203.	66.5	10077.	6352.	89.4		
17	C.8	MC	5000.			64.8	9162.	5703.	61.6	9328.	5872.	82.9		
18	C.8	MC	1500.			61.5	8682.	5405.	58.6	8852.	5572.	78.8		
19	C.8	W1	10000.			70.0	3640.	1383.	36.2	1946.	739.	49.8	2263.	954.
20	C.8	W1	5000.			64.8	3351.	1286.	33.6	1814.	699.	46.3	2111.	836.
21	C.8	W1	1500.			61.5	3168.	1216.	31.9	1730.	667.	44.0	2014.	798.
22	C.8	W2	10000.			70.0	2970.	1185.	30.0	464.	215.	30.0	464.	215.
23	C.8	W2	5000.			64.8	2731.	1067.	30.0	502.	224.	30.0	502.	224.
24	C.8	W2	1500.			61.5	2579.	1008.	30.0	532.	237.	30.0	532.	237.
25	C.8	W3	10000.			70.0	2970.	1185.	30.0	464.	215.	30.0	464.	215.
26	C.8	W3	5000.			64.8	2731.	1067.	30.0	502.	224.	30.0	502.	224.
27	C.8	W3	1500.			61.5	2579.	1008.	30.0	532.	237.	30.0	532.	237.

TABLE IV-36
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 20000. FT

WC = 625000. LBS			DESIGN ALTITUDE, H3 = 20000. FT						LS/WO		VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	20000.	70.0	3110.	1674.	30.0	476.	209.	30.0	476.	209.	316359.	
2	1.0	10000.	59.5	2604.	1035.	30.0	569.	238.	30.0	569.	238.	316153.	
3	1.0	1500.	52.3	2261.	899.	30.0	663.	278.	30.0	663.	278.	303591.	
4	0.9	20000.	70.0	4706.	2534.	47.0	3800.	1441.	63.7	4393.	1710.		
5	0.9	10000.	59.5	3963.	1579.	40.1	3247.	1250.	54.4	3758.	1477.		
6	0.9	1500.	52.3	3457.	1378.	35.3	2869.	1104.	48.1	3323.	1306.		
7	0.9	20000.	70.0	2916.	1095.	30.0	459.	212.	30.0	459.	212.		
8	0.9	10000.	59.5	2442.	948.	30.0	546.	244.	30.0	546.	244.		
9	0.9	1500.	52.3	2121.	823.	30.0	634.	283.	30.0	634.	283.		
10	0.9	20000.	70.0	2916.	1095.	30.0	459.	212.	30.0	459.	212.		
11	0.9	10000.	59.5	2442.	948.	30.0	546.	244.	30.0	546.	244.		
12	0.9	1500.	52.3	2121.	823.	30.0	634.	283.	30.0	634.	283.		
13	0.9	20000.	70.0	2916.	1095.	30.0	459.	212.	30.0	459.	212.		
14	0.9	10000.	59.5	2442.	948.	30.0	546.	244.	30.0	546.	244.		
15	0.9	1500.	52.3	2121.	823.	30.0	634.	283.	30.0	634.	283.		
16	0.8	20000.	70.0	10458.	5630.	70.0	10658.	6483.	94.1				
17	0.8	10000.	59.5	8852.	3536.	59.7							
18	0.8	1500.	52.3	7754.	3097.	52.6							
19	0.8	20000.	70.0	3909.	1511.	43.1	2820.	1185.	58.7	3266.	1328.		
20	0.8	10000.	59.5	3288.	1308.	36.8	2417.	931.	50.2	2804.	1155.		
21	0.8	1500.	52.3	2866.	1140.	32.4	2142.	825.	44.4	2488.	1025.		
22	0.8	20000.	70.0	2714.	1025.	30.0	441.	210.	30.0	441.	210.		
23	0.8	10000.	59.5	2273.	867.	30.0	522.	241.	30.0	522.	241.		
24	0.8	1500.	52.3	1974.	753.	30.0	604.	280.	30.0	604.	280.		
25	0.8	20000.	70.0	2714.	1025.	30.0	441.	210.	30.0	441.	210.		
26	0.8	10000.	59.5	2273.	867.	30.0	522.	241.	30.0	522.	241.		
27	0.8	1500.	52.3	1974.	753.	30.0	604.	280.	30.0	604.	280.		

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CONVENTIONAL RIGID
TABLE IV-37
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 1500000. LBS		DESIGN ALTITUDE, H3 = 5000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO	LS/WO	H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	5000.	70.0	6051.	4000.	30.0	738.	312.	30.0	738.	312.		
2	1.0	3000.	67.9	5856.	3871.	30.0	767.	325.	30.0	767.	325.		
3	1.0	1500.	66.4	5715.	3778.	30.0	790.	334.	30.0	790.	334.		
4	0.9	5000.	70.0	10574.	6990.	51.3	9222.	5742.	69.1	10626.	7034.		
5	0.9	3000.	67.9	10246.	6990.	49.8	8948.	5742.	67.1	10311.	7034.		
6	0.9	1500.	66.4	10009.	6616.	48.8	8751.	5449.	65.6	10084.	6576.		
7	0.9	5000.	70.0	5674.	2191.	30.0	704.	305.	30.0	704.	305.		
8	0.9	3000.	67.9	5491.	2191.	30.0	732.	305.	30.0	732.	305.		
9	0.9	1500.	66.4	5359.	2069.	30.0	753.	326.	30.0	753.	326.		
10	0.9	5000.	70.0	5674.	2191.	30.0	704.	305.	30.0	704.	305.		
11	0.9	3000.	67.9	5491.	2191.	30.0	732.	305.	30.0	732.	305.		
12	0.9	1500.	66.4	5359.	2069.	30.0	753.	326.	30.0	753.	326.		
13	0.9	5000.	70.0	5674.	2191.	30.0	704.	305.	30.0	704.	305.		
14	0.9	3000.	67.9	5491.	2191.	30.0	732.	305.	30.0	732.	305.		
15	0.9	1500.	66.4	5359.	2069.	30.0	753.	326.	30.0	753.	326.		
16	0.8	5000.	70.0	26483.	17505.	76.5	3386.	1328.	49.7	3917.	1498.		
17	0.8	3000.	67.9	25684.	17535.	74.2	3289.	1328.	48.2	3806.	1498.		
18	0.8	1500.	66.4	25108.	16596.	72.6	3219.	1262.	47.2	3726.	1425.		
19	0.8	5000.	70.0	6513.	2504.	36.6	669.	297.	30.0	669.	297.		
20	0.8	3000.	67.9	6306.	2504.	35.5	695.	297.	30.0	695.	297.		
21	0.8	1500.	66.4	6157.	2368.	34.7	715.	317.	30.0	715.	317.		
22	0.8	5000.	70.0	5280.	2052.	30.0	669.	297.	30.0	669.	297.		
23	0.8	3000.	67.9	5110.	2052.	30.0	695.	297.	30.0	695.	297.		
24	0.8	1500.	66.4	4987.	1938.	30.0	715.	317.	30.0	715.	317.		
25	0.8	5000.	70.0	5280.	2052.	30.0	669.	297.	30.0	669.	297.		
26	0.8	3000.	67.9	5110.	2052.	30.0	695.	297.	30.0	695.	297.		
27	0.8	1500.	66.4	4987.	1938.	30.0	715.	317.	30.0	715.	317.		

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TABLE IV-38
DESIGN VMAX = 70. KNOTS

CONVENTIONAL			RIGID	DESIGN ALTITUDE, H3 = 10000. FT				RECIPROCATING - COMPOUND ENGINE			
WGT = 1500000. LBS				DESIGN VMAX = 70. KNOTS							
1	2	3	4	5	6	7	8	9	10	11	12
LS/WGT		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	10000.	5804.	3630.	30.0	716.	316.	30.0	716.	316.
2	1.0	W0	5000.	5336.	3311.	30.0	791.	332.	30.0	791.	332.
3	1.0	W0	1500.	5040.	3128.	30.0	848.	357.	30.0	848.	357.
4	C-5	W0	10000.	10600.	6631.	52.6	9471.	4790.	70.7		
5	C-5	W0	5000.	9779.	6081.	48.8	8767.	4866.	65.6		
6	C-5	W0	1500.	9257.	5757.	46.3	8320.	4618.	62.4		
7	C-9	W1	10000.	5441.	2098.	30.0	684.	309.	30.0	684.	309.
8	C-9	W1	5000.	5003.	1913.	30.0	754.	326.	30.0	754.	326.
9	C-9	W1	1500.	4725.	1807.	30.0	808.	350.	30.0	808.	350.
10	C-5	W2	10000.	5441.	2098.	30.0	684.	309.	30.0	684.	309.
11	C-5	W2	5000.	5003.	1913.	30.0	754.	326.	30.0	754.	326.
12	C-5	W2	1500.	4725.	1807.	30.0	808.	350.	30.0	808.	350.
13	C-5	W3	10000.	5441.	2098.	30.0	684.	309.	30.0	684.	309.
14	C-9	W3	5000.	5003.	1913.	30.0	754.	326.	30.0	754.	326.
15	C-9	W3	1500.	4725.	1807.	30.0	808.	350.	30.0	808.	350.
16	C-8	W0	10000.	27384.	17129.	78.3					
17	C-8	W0	5000.	25320.	15769.	72.7					
18	C-8	W0	1500.	24007.	14952.	69.0					
19	C-8	W1	10000.	6708.	2619.	39.8	4103.	1636.	54.0	4741.	1822.
20	C-8	W1	5000.	6178.	2363.	36.9	3807.	1484.	50.1	4401.	1684.
21	C-8	W1	1500.	5842.	2235.	35.1	3618.	1411.	47.6	4185.	1602.
22	C-8	W2	10000.	5063.	1921.	30.0	650.	301.	30.0	650.	301.
23	C-8	W2	5000.	4655.	1787.	30.0	716.	318.	30.0	716.	318.
24	C-8	W2	1500.	4397.	1688.	30.0	766.	340.	30.0	766.	340.
25	C-8	W3	10000.	5063.	1921.	30.0	650.	301.	30.0	650.	301.
26	C-8	W3	5000.	4655.	1787.	30.0	716.	318.	30.0	716.	318.
27	C-8	W3	1500.	4397.	1688.	30.0	766.	340.	30.0	766.	340.

TABLE IV-39
DESIGN VMAX = 70. KNOTS

TABLE IV-39
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

CONVENTIONAL RIGID

DESIGN ALTITUDE, H3 = 20000. FT

SAT - 000005T = 04

1	2	3	4	5	6	7	8	9	10	11	12
LS/KG		H FL	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	20000	70.0	5314	2861	30.0	673	303	30.0	673	303
2	1-O	10000	59.5	4450	1769	30.0	830	357	30.0	830	357
3	1-E	1500	52.3	3864	1536	30.0	992	427	30.0	992	427
4	C-S	20000	70.0	10733	5778	55.3	10020	3901	74.4		
5	C-S	10000	59.5	9057	3613	47.2	8512	3342	63.5		
6	C-S	1500	52.3	7915	3157	41.6	7481	2937	56.0		
7	C-S	20000	70.0	4982	2029	30.0	643	299	30.0	643	299
8	C-S	10000	59.5	4171	1579	30.0	791	355	30.0	791	355
9	C-S	1500	52.3	3622	1372	30.0	942	423	30.0	942	423
10	C-S	20000	70.0	4982	2029	30.0	643	299	30.0	643	299
11	C-S	10000	59.5	4171	1579	30.0	791	355	30.0	791	355
12	C-S	1500	52.3	3622	1372	30.0	942	423	30.0	942	423
13	C-S	20000	70.0	4982	2029	30.0	643	299	30.0	643	299
14	C-S	10000	59.5	4171	1579	30.0	791	355	30.0	791	355
15	C-S	1500	52.3	3622	1372	30.0	942	423	30.0	942	423
16	C-S	20000	70.0	29517	15891	82.4					
17	C-S	10000	59.5	25021	10001	70.3					
18	C-S	1500	52.3	21943	8771	62.0					
19	C-S	20000	70.0	7637	2874	47.6	6156	2480	64.3	7102	2743
20	C-S	10000	59.5	6432	2511	40.6	5241	2146	54.9	6050	2399
21	C-S	1500	52.3	5611	2191	35.8	4616	1890	48.4	5331	2114
22	C-S	20000	70.0	4635	1808	30.0	612	289	30.0	612	289
23	C-S	10000	59.5	3881	1553	30.0	750	343	30.0	750	343
24	C-S	1500	52.3	3370	1348	30.0	891	407	30.0	891	407
25	C-S	20000	70.0	4635	1808	30.0	612	289	30.0	612	289
26	C-S	10000	59.5	3881	1553	30.0	750	343	30.0	750	343
27	C-S	1500	52.3	3370	1348	30.0	891	407	30.0	891	407

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TABLE IV-40
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		DESIGN ALTITUDE, H3 = 5000. FT		RECIPROCATING - COMPOUND ENGINE					
1	2	3	4	5	6	7	8	9	10	11	12
LS/NO	W	H	VMAX	RHP	FUEL	VMIN	BHP	FUEL	V(MAX RGE)	RHP	FUEL
		FT.	KNOTS		FLW/HR	KNOTS		FLW/HR	KNOTS		FLW/HR
1	1.0	5000.	140.0	12206.	8068.	30.0	381.	174.	30.0	381.	174.
2	1.0	3000.	135.9	11938.	8068.	30.0	391.	174.	30.0	391.	174.
3	1.0	1500.	132.9	11741.	7761.	30.0	399.	182.	30.0	399.	182.
4	0.5	5000.	140.0	11648.	7700.	36.6	1360.	543.	50.9	1590.	614.
5	0.5	3000.	135.9	11393.	7700.	35.6	1325.	543.	49.5	1550.	614.
6	0.5	1500.	132.9	11206.	7407.	34.8	1299.	519.	48.5	1520.	587.
7	0.5	5000.	140.0	11484.	7546.	30.0	486.	218.	32.9	527.	236.
8	0.5	3000.	135.9	11232.	7546.	30.0	488.	218.	32.1	519.	236.
9	0.5	1500.	132.9	11047.	7259.	30.0	491.	221.	31.5	514.	230.
10	0.5	5000.	140.0	11463.	7527.	30.0	370.	169.	30.0	370.	169.
11	0.5	3000.	135.9	11212.	7527.	30.0	379.	169.	30.0	379.	169.
12	0.5	1500.	132.9	11027.	7240.	30.0	387.	176.	30.0	387.	176.
13	0.9	5000.	140.0	11463.	7527.	30.0	370.	169.	30.0	370.	169.
14	0.9	3000.	135.9	11212.	7527.	30.0	379.	169.	30.0	379.	169.
15	0.9	1500.	132.9	11027.	7240.	30.0	387.	176.	30.0	387.	176.
16	0.8	5000.	140.0	11489.	7594.	54.5	3372.	1368.	73.9	4084.	1576.
17	0.8	3000.	135.9	11239.	7594.	52.9	3469.	1368.	71.9	3992.	1576.
18	0.8	1500.	132.9	11056.	7358.	51.8	3396.	1301.	70.3	3925.	1515.
19	0.8	5000.	140.0	11013.	7163.	43.1	1925.	741.	59.2	2238.	879.
20	0.8	3000.	135.9	10772.	7163.	41.9	1873.	741.	57.5	2178.	879.
21	0.8	1500.	132.9	10595.	6892.	41.0	1835.	707.	56.3	2135.	838.
22	0.6	5000.	140.0	10748.	6966.	30.0	695.	304.	40.6	824.	354.
23	0.6	3000.	135.9	10512.	6966.	30.0	684.	304.	39.5	807.	354.
24	0.6	1500.	132.9	10340.	6702.	30.0	677.	296.	38.7	795.	342.
25	0.6	5000.	140.0	10689.	6922.	30.0	358.	164.	30.0	358.	164.
26	0.6	3000.	135.9	10454.	6922.	30.0	367.	164.	30.0	367.	164.
27	0.6	1500.	132.9	10282.	6659.	30.0	374.	171.	30.0	374.	171.

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CONVENTIONAL RIGID
 TABLE IV-41
 DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

W0 = 250000. LBS DESIGN ALTITUDE, H3 = 10000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/MO	W0	H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL LBS/HR
1	1-C	10000.	140.0	11675.	7303.	30.0	373.	177.	30.0	373.	177.
2	1-C	5000.	129.6	11025.	6957.	30.0	399.	182.	30.0	399.	182.
3	1-C	1500.	123.0	10596.	6686.	30.0	418.	191.	30.0	418.	191.
4	0.9	10000.	140.0	11157.	6979.	37.5	1391.	577.	52.2	1626.	653.
5	0.9	5000.	129.6	10537.	6650.	34.8	1301.	526.	48.5	1522.	596.
6	0.9	1500.	123.0	10128.	6392.	33.1	1243.	502.	46.2	1456.	570.
7	0.9	10000.	140.0	10991.	6827.	30.0	526.	244.	35.2	597.	274.
8	0.9	5000.	129.6	10379.	6489.	30.0	527.	236.	33.0	572.	255.
9	0.9	1500.	123.0	9976.	6236.	30.0	531.	238.	31.6	556.	248.
10	0.9	10000.	140.0	10962.	6787.	30.0	363.	171.	30.0	363.	171.
11	0.9	5000.	129.6	10352.	6461.	30.0	387.	176.	30.0	387.	176.
12	0.9	1500.	123.0	9949.	6210.	30.0	405.	184.	30.0	405.	184.
13	0.9	10000.	140.0	10962.	6787.	30.0	363.	171.	30.0	363.	171.
14	0.9	5000.	129.6	10352.	6461.	30.0	387.	176.	30.0	387.	176.
15	0.9	1500.	123.0	9949.	6210.	30.0	405.	184.	30.0	405.	184.
16	0.8	10000.	140.0	11061.	6919.	55.9	3662.	1425.	75.8	4165.	1576.
17	0.8	5000.	129.6	10451.	6597.	51.8	3400.	1299.	70.3	3929.	1513.
18	0.8	1500.	123.0	10048.	6343.	49.2	3233.	1236.	66.9	3741.	1441.
19	0.8	10000.	140.0	10585.	6308.	45.0	2079.	784.	61.7	2404.	921.
20	0.8	5000.	129.6	9998.	6140.	41.8	1928.	742.	57.4	2241.	875.
21	0.8	1500.	123.0	9611.	5902.	39.7	1838.	717.	54.6	2138.	835.
22	0.8	10000.	140.0	10304.	5955.	30.9	839.	374.	44.3	993.	434.
23	0.8	5000.	129.6	9731.	5878.	30.0	792.	342.	41.3	938.	398.
24	0.8	1500.	123.0	9353.	5649.	30.0	767.	332.	39.4	902.	383.
25	0.8	10000.	140.0	10218.	5868.	30.0	352.	166.	30.0	352.	166.
26	0.8	5000.	129.6	9650.	5798.	30.0	374.	170.	30.0	374.	170.
27	0.8	1500.	123.0	9274.	5573.	30.0	391.	178.	30.0	391.	178.

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TABLE IV-42
DESIGN VMAX = 140. KNOTS

CONVENTIONAL			RIGID		RECIPROCATING - COMPOUND ENGINE									
WC = 250000. LBS			DESIGN ALTITUDE, H3 = 20000. FT											
1	2	3	4	5	6	7	8	9	10	11	12			
LS/MO		H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/MO	VOLUME	WF+PL
1	1-C	20000.	140.0	10640.	5728.	30.0	358.	172.	30.0	358.	172.	1-C	7897678.	36388.
2	1-C	10000.	118.9	9412.	3833.	30.0	411.	193.	30.0	411.	193.	0.9	7137908.	44420.
3	1-C	1500.	104.5	8502.	3462.	30.0	465.	219.	30.0	465.	219.	0.8	6318140.	52192.
4	C-5	20000.	140.0	10203.	5493.	39.5	1461.	605.	54.8	1705.	682.			
5	C-5	10000.	118.9	9028.	3677.	33.7	1267.	529.	47.1	1484.	601.			
6	C-9	1500.	104.5	8158.	3323.	30.0	1135.	474.	41.7	1332.	539.			
7	C-9	20000.	140.0	10053.	4240.	30.0	729.	334.	42.3	867.	390.			
8	C-9	10000.	118.9	8893.	3599.	30.0	673.	305.	36.6	775.	346.			
9	C-9	1500.	104.5	8034.	3251.	30.0	661.	299.	32.6	712.	318.			
10	C-9	20000.	140.0	9889.	3969.	30.0	364.	174.	30.0	364.	174.			
11	C-5	10000.	118.9	8836.	3565.	30.0	409.	192.	30.0	409.	192.			
12	C-5	1500.	104.5	7982.	3221.	30.0	458.	215.	30.0	458.	215.			
13	C-5	20000.	140.0	9986.	3567.	30.0	348.	167.	30.0	348.	167.			
14	C-5	10000.	118.9	8833.	3564.	30.0	398.	187.	30.0	398.	187.			
15	C-9	1500.	104.5	7979.	3219.	30.0	449.	211.	30.0	449.	211.			
16	C-8	20000.	140.0	10243.	5514.	58.9	3863.	1487.	79.8	4343.	1627.			
17	C-8	10000.	118.9	9073.	3697.	50.2	3301.	1305.	68.2	3819.	1455.			
18	C-8	1500.	104.5	8205.	3343.	44.2	2916.	1153.	60.2	3377.	1287.			
19	C-8	20000.	140.0	9816.	3860.	50.3	2540.	952.	68.7	2945.	1219.			
20	C-8	10000.	118.9	8690.	3475.	42.9	2181.	632.	58.8	2532.	1759.			
21	C-8	1500.	104.5	7855.	3141.	37.8	1935.	738.	51.9	2250.	941.			
22	C-8	20000.	140.0	9518.	3702.	40.2	1427.	595.	55.7	1667.	671.			
23	C-8	10000.	118.9	8422.	3325.	34.2	1239.	520.	47.8	1451.	591.			
24	C-8	1500.	104.5	7611.	3005.	30.2	1110.	466.	42.4	1304.	531.			
25	C-8	20000.	140.0	9348.	3624.	30.0	589.	275.	39.9	700.	322.			
26	C-8	10000.	118.9	8270.	3255.	30.0	566.	260.	34.6	634.	289.			
27	C-8	1500.	104.5	7471.	2941.	30.0	572.	263.	30.9	589.	268.			

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TABLE IV-43
DESIGN VMAX = 140. KNOTS

CONVENTIONAL			RIGID		DESIGN ALTITUDE, H3 = 5000. FT				RECIPROCATING - COMPOUND ENGINE			
W0 = 625000. LBS			DESIGN ALTITUDE, H3 = 5000. FT		DESIGN VMAX = 140. KNOTS				DESIGN VMAX = 140. KNOTS			
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	5000.	140.0	21179.	13999.	30.0	515.	232.	30.0	515.	232.	
2	1.0	3000.	135.5	20713.	13999.	30.0	532.	232.	30.0	532.	232.	
3	1.0	1500.	132.9	20371.	13465.	30.0	546.	246.	30.0	546.	246.	
4	0.5	5000.	140.0	20498.	13549.	43.5	3509.	1340.	59.1	4058.	1561.	
5	0.5	3000.	135.5	20049.	13549.	42.3	3409.	1340.	57.4	3943.	1561.	
6	0.5	1500.	132.9	19720.	13035.	41.4	3336.	1275.	56.2	3860.	1485.	
7	0.5	5000.	140.0	19870.	12965.	30.0	496.	223.	30.0	496.	223.	
8	0.5	3000.	135.5	19433.	12965.	30.0	512.	223.	30.0	512.	223.	
9	0.5	1500.	132.9	19113.	12471.	30.0	524.	236.	30.0	524.	236.	
10	0.5	5000.	140.0	19870.	12965.	30.0	496.	223.	30.0	496.	223.	
11	0.5	3000.	135.5	19433.	12965.	30.0	512.	223.	30.0	512.	223.	
12	0.5	1500.	132.9	19113.	12471.	30.0	524.	236.	30.0	524.	236.	
13	0.5	5000.	140.0	19870.	12965.	30.0	496.	223.	30.0	496.	223.	
14	0.5	3000.	135.5	19433.	12965.	30.0	512.	223.	30.0	512.	223.	
15	0.5	1500.	132.9	19113.	12471.	30.0	524.	236.	30.0	524.	236.	
16	0.8	5000.	140.0	21221.	14027.	64.8	9815.	3759.	87.2	10751.	4141.	
17	0.8	3000.	135.5	20761.	14027.	63.0	9523.	3759.	84.7	10508.	4141.	
18	0.8	1500.	132.9	20424.	13500.	61.6	9313.	3566.	82.9	10331.	3979.	
19	0.8	5000.	140.0	19078.	12134.	43.3	3237.	1271.	58.9	3746.	1432.	
20	0.8	3000.	135.5	18660.	12134.	42.1	3145.	1271.	57.2	3640.	1432.	
21	0.8	1500.	132.9	18354.	11674.	41.2	3079.	1209.	56.0	3564.	1363.	
22	0.8	5000.	140.0	18505.	11523.	30.0	475.	215.	30.0	475.	215.	
23	0.8	3000.	135.5	18098.	11523.	30.0	490.	215.	30.0	490.	215.	
24	0.8	1500.	132.9	17800.	11084.	30.0	502.	227.	30.0	502.	227.	
25	0.8	5000.	140.0	18505.	11523.	30.0	475.	215.	30.0	475.	215.	
26	0.8	3000.	135.5	18098.	11523.	30.0	490.	215.	30.0	490.	215.	
27	0.8	1500.	132.9	17800.	11084.	30.0	502.	227.	30.0	502.	227.	

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TABLE IV-44
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE									
WG = 625000. LBS		DESIGN ALTITUDE, H3 = 10000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/WO	MF+PL
1	1.0	10000.	140.0	20291.	12692.	30.0	502.	235.	30.0	502.	235.	1.0	241491.
2	1.0	5000.	129.6	19159.	12089.	30.0	546.	245.	30.0	546.	245.	0.9	249352.
3	1.0	1500.	123.0	18412.	11618.	30.0	580.	260.	30.0	580.	260.	0.8	256719.
4	0.9	10000.	140.0	15695.	12320.	44.6	360.	1430.	60.5	4163.	1592.		
5	0.9	5000.	129.6	18601.	11739.	41.4	3342.	1298.	56.2	3867.	1481.		
6	0.9	1500.	123.0	17879.	11283.	39.3	3178.	1234.	53.4	3678.	1409.		
7	0.9	10000.	140.0	19034.	11528.	30.0	483.	226.	30.0	483.	226.		
8	0.9	5000.	129.6	17973.	11102.	30.0	525.	236.	30.0	525.	236.		
9	0.9	1500.	123.0	17272.	10670.	30.0	556.	250.	30.0	556.	250.		
10	0.9	10000.	140.0	15034.	11528.	30.0	483.	226.	30.0	483.	226.		
11	0.9	5000.	129.6	17973.	11102.	30.0	525.	236.	30.0	525.	236.		
12	0.9	1500.	123.0	17272.	10670.	30.0	556.	250.	30.0	556.	250.		
13	0.9	10000.	140.0	19034.	11528.	30.0	483.	226.	30.0	483.	226.		
14	0.9	5000.	129.6	17973.	11102.	30.0	525.	236.	30.0	525.	236.		
15	0.9	1500.	123.0	17272.	10670.	30.0	556.	250.	30.0	556.	250.		
16	0.8	10000.	140.0	20582.	12875.	66.5	10077.	3935.	89.4	10971.	4187.		
17	0.8	5000.	129.6	19453.	12283.	61.6	9328.	3564.	82.9	10347.	3969.		
18	0.8	1500.	123.0	18707.	11812.	58.6	8852.	3392.	78.8	9938.	3812.		
19	0.8	10000.	140.0	18400.	9347.	45.7	3597.	1444.	62.1	4160.	1411.		
20	0.8	5000.	129.6	17379.	10144.	42.4	3340.	1310.	57.6	3863.	1477.		
21	0.8	1500.	123.0	16704.	9750.	40.3	3176.	1246.	54.8	3676.	1406.		
22	0.8	10000.	140.0	17724.	7250.	30.0	464.	218.	30.0	464.	218.		
23	0.8	5000.	129.6	16735.	8301.	30.0	502.	227.	30.0	502.	227.		
24	0.8	1500.	123.0	16083.	7978.	30.0	532.	240.	30.0	532.	240.		
25	0.8	10000.	140.0	17724.	7250.	30.0	464.	218.	30.0	464.	218.		
26	0.8	5000.	129.6	16735.	8301.	30.0	502.	227.	30.0	502.	227.		
27	0.8	1500.	123.0	16083.	7978.	30.0	532.	240.	30.0	532.	240.		

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TABLE IV-45
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE											
WC = 625000. LBS		DESIGN ALTITUDE, H3 = 20000. FT													
1	2	3	4	5	6	7	8	9	10	11	12				
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL LBS/HR	LS/WO	VOLUME	WF+PL	
												1.0	19744192.	196713.	
												0.9	17762760.	210074.	
												0.8	15795354.	219279.	
1	1.0	20000.	140.0	18546.	9984.	30.0	476.	276.	30.0	476.	276.				
2	1.0	10000.	118.9	16402.	6679.	30.0	569.	263.	30.0	569.	263.				
3	1.0	1500.	104.5	14814.	6033.	30.0	663.	307.	30.0	663.	307.				
4	0.5	20000.	140.0	18129.	9760.	47.0	3800.	1582.	63.7	4393.	1771.				
5	0.5	10000.	118.9	16044.	6535.	40.1	3247.	1366.	54.4	3758.	1538.				
6	0.5	1500.	104.5	14498.	5905.	35.3	2869.	1207.	48.1	3323.	1360.				
7	0.5	20000.	140.0	17412.	6853.	30.0	566.	269.	30.0	566.	269.				
8	0.5	10000.	118.9	15399.	6161.	30.0	623.	290.	30.0	623.	290.				
9	0.5	1500.	104.5	13909.	5565.	30.0	694.	323.	30.0	694.	323.				
10	0.5	20000.	140.0	17393.	6842.	30.0	459.	221.	30.0	459.	221.				
11	0.5	10000.	118.9	15383.	6151.	30.0	546.	256.	30.0	546.	256.				
12	0.5	1500.	104.5	13894.	5556.	30.0	634.	297.	30.0	634.	297.				
13	0.5	20000.	140.0	17393.	6842.	30.0	459.	221.	30.0	459.	221.				
14	0.5	10000.	118.9	15383.	6151.	30.0	546.	256.	30.0	546.	256.				
15	0.5	1500.	104.5	13894.	5556.	30.0	634.	297.	30.0	634.	297.				
16	0.8	20000.	140.0	19377.	10432.	70.0	10658.	4156.	94.1	11448.	4315.				
17	0.8	10000.	118.9	17179.	7003.	59.7	9052.	3609.	80.3	10119.	3922.				
18	0.8	1500.	104.5	15547.	6338.	52.6	7954.	3171.	70.8	9146.	3545.				
19	0.8	20000.	140.0	17195.	6620.	51.9	4647.	1749.	70.1	5364.	2188.				
20	0.8	10000.	118.9	15220.	5967.	44.2	3964.	1545.	59.9	4581.	1732.				
21	0.8	1500.	104.5	13757.	5393.	39.0	3497.	1363.	52.9	4045.	1529.				
22	0.8	20000.	140.0	16238.	6181.	30.0	714.	331.	34.6	799.	367.				
23	0.8	10000.	118.9	14362.	5583.	30.0	719.	327.	30.0	719.	327.				
24	0.8	1500.	104.5	12973.	5043.	30.0	756.	345.	30.0	756.	345.				
25	0.8	20000.	140.0	16190.	6161.	30.0	441.	211.	30.0	441.	211.				
26	0.8	10000.	118.9	14319.	5564.	30.0	522.	243.	30.0	522.	243.				
27	0.8	1500.	104.5	12933.	5026.	30.0	604.	282.	30.0	604.	282.				

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TABLE IV-46
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE											
				DESIGN ALTITUDE, H3 = 5000. FT											
W0 = 1500000. LBS															
1	2	3	4	5	6	7	8	9	10	11	12				
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR				
1	1-C	5000.	140.0	36079.	23848.	30.0	738.	325.	30.0	738.	325.				
2	1-C	3000.	135.9	35285.	23848.	30.0	767.	325.	30.0	767.	325.				
3	1-C	1500.	132.9	34702.	22538.	30.0	790.	348.	30.0	790.	348.				
4	0.9	5000.	140.0	35848.	23695.	51.3	9222.	3557.	69.1	10626.	4139.				
5	0.9	3000.	135.9	35064.	23695.	49.8	8948.	3557.	67.1	10311.	4139.				
6	0.9	1500.	132.9	34485.	22797.	48.8	8751.	3376.	65.6	10084.	3928.				
7	0.9	5000.	140.0	33831.	21955.	30.0	704.	312.	30.0	704.	312.				
8	0.9	3000.	135.9	33086.	21955.	30.0	732.	312.	30.0	732.	312.				
9	0.9	1500.	132.9	32540.	21118.	30.0	753.	333.	30.0	753.	333.				
10	0.9	5000.	140.0	33831.	21955.	30.0	704.	312.	30.0	704.	312.				
11	0.9	3000.	135.9	33086.	21955.	30.0	732.	312.	30.0	732.	312.				
12	0.9	1500.	132.9	32540.	21118.	30.0	753.	333.	30.0	753.	333.				
13	0.9	5000.	140.0	33831.	21955.	30.0	704.	312.	30.0	704.	312.				
14	0.9	3000.	135.9	33086.	21955.	30.0	732.	312.	30.0	732.	312.				
15	0.9	1500.	132.9	32540.	21118.	30.0	753.	333.	30.0	753.	333.				
16	0.8	5000.	140.0	40211.	26580.	76.5	25896.	10308.	102.5	27644.	11124.				
17	0.8	3000.	135.9	39349.	26580.	74.2	25284.	10308.	99.6	27035.	11124.				
18	0.8	1500.	132.9	38717.	25592.	72.6	24838.	9887.	97.4	26597.	10700.				
19	0.8	5000.	140.0	32830.	19371.	45.2	6022.	2304.	60.9	6947.	2716.				
20	0.8	3000.	135.9	31915.	19371.	43.8	5846.	2304.	59.2	6744.	2716.				
21	0.8	1500.	132.9	31391.	18635.	42.9	5719.	2188.	57.9	6599.	2580.				
22	0.8	5000.	140.0	31485.	17854.	30.0	669.	297.	30.0	669.	297.				
23	0.8	3000.	135.9	30792.	17854.	30.0	695.	297.	30.0	695.	297.				
24	0.8	1500.	132.9	30284.	17173.	30.0	715.	317.	30.0	715.	317.				
25	0.8	5000.	140.0	31485.	17854.	30.0	669.	297.	30.0	669.	297.				
26	0.8	3000.	135.9	30792.	17854.	30.0	695.	297.	30.0	695.	297.				
27	0.8	1500.	132.9	30284.	17173.	30.0	715.	317.	30.0	715.	317.				

11/28/67

CONVENTIONAL

DESIGN VMAX = 140. KNOTS

TABLE IV-47

RIGID		RECIPROCATING - COMPOUND ENGINE											
DESIGN ALTITUDE, H3 = 10000. FT													
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MO	WC	H	VMAX	BHP	FUEL	V (MIN BHP)	BHP	FUEL	V (MAX RGE)	BHP	FUEL	WF+PL	
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR		
1	1-C	10000.	140.0	34598.	21642.	30.0	716.	328.	30.0	716.	328.	739554.	
2	1-0	5000.	129.6	32666.	20612.	30.0	791.	347.	30.0	791.	347.	739006.	
3	1-0	1500.	123.0	31392.	19809.	30.0	848.	372.	30.0	848.	372.	734640.	
4	0-5	10000.	140.0	34563.	21620.	52.6	9471.	3800.	70.7	10889.	4410.		
5	0-5	5000.	129.6	32647.	20605.	48.8	8767.	3365.	65.6	10103.	3863.		
6	0-9	1500.	123.0	31382.	19807.	46.3	8320.	3193.	62.4	9589.	3667.		
7	0-5	10000.	140.0	32440.	18855.	30.0	684.	314.	30.0	684.	314.		
8	0-5	5000.	129.6	30628.	18581.	30.0	754.	332.	30.0	754.	332.		
9	0-5	1500.	123.0	29433.	17856.	30.0	808.	356.	30.0	808.	356.		
10	0-5	10000.	140.0	32440.	18855.	30.0	684.	314.	30.0	684.	314.		
11	0-5	5000.	129.6	30628.	18581.	30.0	754.	332.	30.0	754.	332.		
12	0-5	1500.	123.0	29433.	17856.	30.0	808.	356.	30.0	808.	356.		
13	0-5	10000.	140.0	32440.	18855.	30.0	684.	314.	30.0	684.	314.		
14	0-9	5000.	129.6	30628.	18581.	30.0	754.	332.	30.0	754.	332.		
15	0-5	1500.	123.0	29433.	17856.	30.0	808.	356.	30.0	808.	356.		
16	0-8	10000.	140.0	33373.	24629.	78.3	26456.	10285.	105.0	28202.	10965.		
17	0-8	5000.	129.6	31236.	23519.	72.7	24884.	9827.	97.4	26639.	10599.		
18	0-8	1500.	123.0	30823.	22627.	69.0	23787.	9393.	92.6	25611.	10190.		
19	0-8	10000.	140.0	31569.	12516.	47.9	6819.	2620.	64.6	7863.	3137.		
20	0-8	5000.	129.6	29815.	12227.	44.4	6317.	2417.	59.9	7285.	2842.		
21	0-8	1500.	123.0	28658.	11753.	42.2	5997.	2295.	57.0	6919.	2699.		
22	0-8	10000.	140.0	30187.	11857.	30.0	650.	300.	30.0	650.	300.		
23	0-8	5000.	129.6	28502.	11433.	30.0	716.	317.	30.0	716.	317.		
24	0-8	1500.	123.0	27390.	10987.	30.0	766.	339.	30.0	766.	339.		
25	0-8	10000.	140.0	30187.	11857.	30.0	650.	300.	30.0	650.	300.		
26	0-8	5000.	129.6	28502.	11433.	30.0	716.	317.	30.0	716.	317.		
27	0-8	1500.	123.0	27390.	10987.	30.0	766.	339.	30.0	766.	339.		

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TABLE IV-48
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		RECIPROCATING - COMPOUND ENGINE									
W0 = 1500000. LBS		DESIGN ALTITUDE, H3 = 20000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WFAPL	
1 1.0	W0	20000.	140.0	31674.	17052.	30.0	673.	317.	30.0	673.	317.	637375.	
2 1.0	W0	10000.	118.5	28010.	11406.	30.0	830.	379.	30.0	830.	379.	650081.	
3 1.0	W0	1500.	104.5	25297.	10301.	30.0	992.	452.	30.0	992.	452.	654043.	
4 0.9	W0	20000.	140.0	32060.	17266.	55.3	10020.	4009.	74.4	11393.	4374.		
5 0.5	W0	10000.	118.5	28383.	11563.	47.2	8512.	3284.	63.5	9810.	3867.		
6 0.5	W0	1500.	104.5	25656.	10452.	41.6	7481.	2886.	56.0	8624.	3400.		
7 0.5	W1	20000.	140.0	29693.	11543.	30.0	643.	301.	30.0	643.	301.		
8 0.5	W1	10000.	118.5	26259.	10360.	30.0	791.	358.	30.0	791.	358.		
9 0.5	W1	1500.	104.5	23715.	9357.	30.0	942.	427.	30.0	942.	427.		
10 0.9	W2	20000.	140.0	29693.	11543.	30.0	643.	301.	30.0	643.	301.		
11 0.5	W2	10000.	118.5	26259.	10360.	30.0	791.	358.	30.0	791.	358.		
12 0.5	W2	1500.	104.5	23715.	9357.	30.0	942.	427.	30.0	942.	427.		
13 0.9	W3	20000.	140.0	29693.	11543.	30.0	643.	301.	30.0	643.	301.		
14 0.5	W3	10000.	118.5	26259.	10360.	30.0	791.	358.	30.0	791.	358.		
15 0.5	W3	1500.	104.5	23715.	9357.	30.0	942.	427.	30.0	942.	427.		
16 0.8	W0	20000.	140.0	37967.	20386.	82.4	27673.	10344.	110.5	29414.	11099.		
17 0.8	W0	10000.	118.5	33621.	13715.	70.3	24319.	9274.	94.3	26081.	10732.		
18 0.8	W0	1500.	104.5	30463.	12426.	62.0	21346.	8140.	83.1	23623.	9087.		
19 0.8	W1	20000.	140.0	29746.	11244.	54.8	9082.	3561.	73.7	10350.	4158.		
20 0.8	W1	10000.	118.5	26333.	10152.	46.7	7718.	3091.	62.9	8897.	3437.		
21 0.8	W1	1500.	104.5	23883.	9176.	41.2	6785.	2717.	55.5	7825.	3023.		
22 0.8	W2	20000.	140.0	27626.	10324.	30.0	612.	289.	30.0	612.	289.		
23 0.8	W2	10000.	118.5	24431.	9319.	30.0	750.	343.	30.0	750.	343.		
24 0.8	W2	1500.	104.5	22065.	8416.	30.0	891.	407.	30.0	891.	407.		
25 0.8	W3	20000.	140.0	27626.	10324.	30.0	612.	289.	30.0	612.	289.		
26 0.8	W3	10000.	118.5	24431.	9319.	30.0	750.	343.	30.0	750.	343.		
27 0.8	W3	1500.	104.5	22065.	8416.	30.0	891.	407.	30.0	891.	407.		

11/28/67

UNAVENTIONAL

RIGID

TABLE IV-4a
DESIGN VMAX = 210. KNOTS

RECIPROCATING - COMPOUND ENGINE

W0 = 625000. LBS

DESIGN ALTITUDE, M3 = 5000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/MG		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RUE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	210.0	67480.	44604.	30.0	515.	234.	30.0	515.	234.
2	1.0	W0	203.8	65304.	44604.	30.0	532.	234.	30.0	532.	234.
3	1.0	W0	199.3	63737.	42130.	30.0	546.	248.	30.0	546.	248.
4	0.9	W0	210.0	63735.	42129.	43.5	3507.	1396.	59.1	4059.	1563.
5	0.9	W0	203.8	61581.	42129.	42.3	3409.	1396.	57.4	3943.	1563.
6	0.9	W0	199.3	60201.	39793.	41.4	3336.	1327.	56.2	3860.	1487.
7	0.9	W1	210.0	63399.	41814.	30.0	1197.	506.	40.0	1399.	579.
8	0.9	W1	203.8	61355.	41814.	30.0	1172.	506.	38.9	1365.	579.
9	0.9	W1	199.3	59883.	39495.	30.0	1156.	489.	38.1	1340.	555.
10	0.9	W2	210.0	63316.	41737.	30.0	496.	235.	30.0	496.	225.
11	0.9	W2	203.8	61275.	41737.	30.0	512.	225.	30.0	512.	225.
12	0.9	W2	199.3	59804.	39422.	30.0	524.	239.	30.0	524.	239.
13	0.9	W3	210.0	63316.	41737.	30.0	496.	225.	30.0	496.	225.
14	0.9	W3	203.8	61275.	41737.	30.0	512.	225.	30.0	512.	225.
15	0.9	W3	199.3	59804.	39422.	30.0	524.	239.	30.0	524.	239.
16	0.8	W0	210.0	60782.	40177.	64.8	9815.	3768.	87.2	10751.	4116.
17	0.8	W0	203.8	58828.	40177.	63.0	9523.	3768.	84.7	10504.	4116.
18	0.8	W0	199.3	57419.	37954.	61.6	9313.	3575.	82.9	10331.	3956.
19	0.8	W1	210.0	59812.	39270.	53.1	5641.	2188.	71.7	6476.	2480.
20	0.8	W1	203.8	57886.	39270.	51.6	5476.	2188.	69.7	6320.	2480.
21	0.8	W1	199.3	56446.	37395.	50.5	5357.	2078.	68.2	6183.	2368.
22	0.8	W2	210.0	59209.	33712.	38.3	2333.	898.	52.4	2703.	1760.
23	0.8	W2	203.8	57301.	33712.	37.2	2269.	890.	51.9	2633.	1060.
24	0.8	W2	199.3	55926.	30565.	36.4	2222.	855.	49.8	2580.	1010.
25	0.8	W3	210.0	58975.	38496.	30.0	504.	228.	30.0	504.	228.
26	0.8	W3	203.8	57074.	38496.	30.0	517.	228.	30.0	517.	228.
27	0.8	W3	199.3	55705.	30561.	30.0	528.	239.	30.0	528.	239.

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CONVENTIONAL		MILID		DESIGN ALTITUDE, H ₃ = 10000. FT		DESIGN VMAX = 210. KNOTS		RECIPROCATING - COMPOUND ENGINE					
W ₀ = 625000. LBS		H FT.		VMAX KNOTS		BHP		LS/WO		VOLUME		WF+PL	
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO	W ₀				FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V MAX KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	10000.	210.0	64643.	40436.	30.0	502.	236.	30.0	502.	236.	171648.	
2	1.0	5000.	194.4	59435.	36886.	30.0	546.	247.	30.0	546.	247.	121051.	
3	1.0	1500.	184.5	56138.	34840.	30.0	580.	262.	30.0	580.	262.	142255.	
4	0.9	10000.	210.0	61085.	38210.	44.6	3600.	1486.	60.5	4163.	1656.		
5	0.9	5000.	194.4	56167.	34860.	41.4	3342.	1346.	56.2	3867.	1512.		
6	0.9	1500.	184.5	53054.	32927.	39.3	3173.	1280.	53.4	3678.	1438.		
7	0.9	10000.	210.0	60762.	37913.	31.7	1475.	630.	43.8	1722.	717.		
8	0.9	5000.	194.4	55868.	34559.	30.0	1379.	573.	40.8	1611.	653.		
9	0.9	1500.	184.5	52770.	32643.	30.0	1325.	551.	38.9	1540.	625.		
10	0.9	10000.	210.0	60645.	37806.	30.0	487.	230.	30.0	487.	230.		
11	0.9	5000.	194.4	55760.	34451.	30.0	528.	240.	30.0	528.	240.		
12	0.9	1500.	184.5	52667.	32540.	30.0	559.	254.	30.0	559.	254.		
13	0.9	10000.	210.0	60645.	37805.	30.0	483.	228.	30.0	483.	228.		
14	0.9	5000.	194.4	55760.	34451.	30.0	525.	238.	30.0	525.	238.		
15	0.9	1500.	184.5	52667.	32540.	30.0	556.	252.	30.0	556.	252.		
16	0.8	10000.	210.0	58379.	36518.	66.5	10077.	4021.	89.4	10971.	4285.		
17	0.8	5000.	194.4	53684.	33326.	61.6	9328.	3640.	82.9	10347.	3954.		
18	0.8	1500.	184.5	50720.	31482.	58.6	8452.	3454.	78.8	9938.	3798.		
19	0.8	10000.	210.0	57449.	35643.	55.9	6215.	2464.	75.3	7057.	2705.		
20	0.8	5000.	194.4	52428.	32464.	51.8	5759.	2232.	69.9	6644.	2545.		
21	0.8	1500.	184.5	49902.	30666.	49.2	5469.	2120.	66.5	6311.	2417.		
22	0.8	10000.	210.0	56827.	34750.	43.0	3038.	1174.	58.4	3517.	1446.		
23	0.8	5000.	194.4	52252.	31895.	39.8	2923.	1113.	54.3	3270.	1311.		
24	0.8	1500.	184.5	49356.	30127.	37.9	2686.	1059.	51.6	3113.	1248.		
25	0.8	10000.	210.0	55514.	34305.	30.0	812.	369.	35.4	919.	414.		
26	0.8	5000.	194.4	51362.	31609.	30.0	800.	352.	33.0	869.	380.		
27	0.8	1500.	184.5	49081.	29857.	30.0	800.	352.	31.5	833.	366.		

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TABLE IV-51
DESIGN VMAX = 210 KNOTS

CONVENTIONAL			RIGID		DESIGN ALTITUDE, H3 = 20000. FT			RECIPROCATING - COMPOUND ENGINE				
DESIGN ALTITUDE, H3 = 20000. FT			DESIGN ALTITUDE, H3 = 20000. FT		DESIGN ALTITUDE, H3 = 20000. FT		DESIGN ALTITUDE, H3 = 20000. FT					
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H	VMAX	BHP	FUEL	V (MIN BHP)	BHP	FUEL	V MAX RGE)	BHP	FUEL	
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR	
1	1.0	20000.	210.0	59069.	31800.	30.0	476.	229.	30.0	476.	229.	
2	1.0	10000.	178.4	49662.	19665.	30.0	569.	266.	30.0	569.	266.	
3	1.0	1500.	156.8	42953.	17077.	30.0	663.	310.	30.0	663.	310.	
4	0.9	20000.	210.0	55892.	30089.	47.0	3800.	1565.	63.7	4393.	1748.	
5	0.9	10000.	178.4	46308.	18611.	40.1	3247.	1353.	54.4	3758.	1521.	
6	0.9	1500.	156.8	40653.	16163.	35.3	2869.	1196.	48.1	3323.	1345.	
7	0.9	20000.	210.0	55623.	27824.	38.3	2201.	875.	52.4	2556.	963.	
8	0.9	10000.	178.4	46580.	18480.	32.6	1894.	765.	44.9	2203.	858.	
9	0.9	1500.	156.8	40453.	16049.	30.0	1688.	682.	39.7	1962.	764.	
10	0.9	20000.	210.0	55459.	26455.	30.0	958.	437.	38.5	1116.	501.	
11	0.9	10000.	178.4	46441.	18401.	30.0	906.	408.	33.1	985.	440.	
12	0.9	1500.	156.8	40330.	15980.	30.0	912.	411.	30.0	912.	408.	
13	0.9	20000.	210.0	55401.	25967.	30.0	461.	221.	30.0	461.	221.	
14	0.9	10000.	178.4	46391.	18373.	30.0	547.	256.	30.0	547.	256.	
15	0.9	1500.	156.8	40287.	15955.	30.0	635.	297.	30.0	635.	297.	
16	0.8	20000.	210.0	53698.	28908.	70.0	10658.	4315.	94.1	11448.	4553.	
17	0.8	10000.	178.4	44992.	17892.	50.7	9052.	3539.	80.3	10119.	4065.	
18	0.8	1500.	156.8	39090.	15545.	52.6	7954.	3109.	70.8	9146.	3674.	
19	0.8	20000.	210.0	52883.	22106.	61.7	7508.	2905.	83.2	8330.	3391.	
20	0.8	10000.	178.4	44300.	17498.	52.6	6386.	2535.	71.0	7344.	2910.	
21	0.8	1500.	156.8	38482.	15200.	46.4	5618.	2231.	62.6	6483.	2480.	
22	0.8	20000.	210.0	52264.	20706.	52.3	4751.	1871.	70.7	5475.	2058.	
23	0.8	10000.	178.4	43774.	17258.	44.6	4052.	1627.	60.4	4683.	1814.	
24	0.8	1500.	156.8	38020.	14990.	39.3	3574.	1436.	53.3	4134.	1601.	
25	0.8	20000.	210.0	51841.	20456.	40.9	2459.	959.	55.9	2952.	1068.	
26	0.8	10000.	178.4	43415.	17095.	34.9	1812.	840.	47.8	2454.	938.	
27	0.8	1500.	156.8	37705.	14846.	30.8	1875.	746.	42.3	2181.	834.	

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TABLE IV-52
DESIGN VMAX = 210. KNOTS

CONVENTIONAL			RIGID		DESIGN ALTITUDE, M3 = 5000. FT		RECIPROCATING - COMPOUND ENGINE					
MC = 1500000. LBS			H		V (MIN BHP)		LS/MO		VOLUME		WF+PL	
1	2	3	4	5	6	7	8	9	10	11	12	
LS/MO		FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1-C	MO	210.0	114858.	75948.	30.0	738.	328.	30.0	738.	328.	
2	1-C	MO	203.8	111191.	75548.	30.0	767.	328.	30.0	767.	328.	
3	1-C	MO	199.3	109519.	71731.	30.0	790.	351.	30.0	790.	351.	
4	C-S	MO	210.0	109088.	72107.	51.3	9222.	3532.	69.1	10626.	4059.	
5	C-S	MO	203.8	105572.	72107.	49.8	8948.	3532.	67.1	10311.	4059.	
6	C-S	MO	199.3	103039.	68108.	48.8	8751.	3532.	65.6	10084.	3852.	
7	C-S	MI	210.0	107863.	70960.	30.0	1715.	687.	37.8	1976.	768.	
8	C-S	MI	203.8	104383.	70560.	30.0	1684.	687.	36.7	1924.	768.	
9	C-S	MI	199.3	101876.	67022.	30.0	1664.	666.	35.9	1887.	733.	
10	C-S	MI	210.0	107744.	70850.	30.0	704.	314.	30.0	704.	314.	
11	C-S	MI	203.8	104267.	70850.	30.0	732.	314.	30.0	732.	314.	
12	C-S	MI	199.3	101763.	66917.	30.0	753.	336.	30.0	753.	336.	
13	C-S	MI	210.0	107744.	70850.	30.0	704.	314.	30.0	704.	314.	
14	C-S	MI	203.8	104267.	70850.	30.0	732.	314.	30.0	732.	314.	
15	C-S	MI	199.3	101763.	66917.	30.0	753.	336.	30.0	753.	336.	
16	C-S	MO	210.0	106096.	70129.	76.5	25886.	9906.	102.5	27644.	10570.	
17	C-S	MO	203.8	102688.	70129.	74.2	25284.	9906.	99.6	27035.	10570.	
18	C-S	MO	199.3	100233.	66254.	72.6	24838.	9502.	97.4	26599.	10167.	
19	C-S	MI	210.0	102544.	66828.	59.9	13232.	5065.	80.4	14770.	5646.	
20	C-S	MI	203.8	99242.	66828.	58.1	12837.	5065.	78.1	14429.	5646.	
21	C-S	MI	199.3	96862.	63125.	56.9	12552.	4805.	76.4	14178.	5420.	
22	C-S	MI	210.0	100637.	65359.	37.1	3523.	1396.	50.4	4075.	1562.	
23	C-S	MI	203.8	97391.	65359.	36.0	3422.	1396.	48.9	3959.	1562.	
24	C-S	MI	199.3	95052.	61732.	35.3	3349.	1327.	47.9	3875.	1485.	
25	C-S	MI	210.0	100279.	65093.	30.0	669.	299.	30.0	669.	299.	
26	C-S	MI	203.8	97043.	65093.	30.0	695.	299.	30.0	695.	299.	
27	C-S	MI	199.3	94712.	61479.	30.0	715.	319.	30.0	715.	319.	

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TABLE IV-53
DESIGN VMAX = 210. KNOTS

CONVENTIONAL			RIGID		DESIGN VMAX = 210. KNOTS					RECIPROCATING - COMPOUND ENGINE				
MC = 1500000. LBS			DESIGN ALTITUDE, H3 = 10000. FT											
1	2	3	4	5	6	7	8	9	10	11	12			
LS/MC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR			
1	1.0	10000.	210.0	110173.	68916.	30.0	716.	330.	30.0	716.	330.			
2	1.0	9000.	194.4	101292.	62861.	30.0	791.	349.	30.0	791.	349.			
3	1.0	1500.	184.5	95669.	59372.	30.0	848.	374.	30.0	848.	374.			
4	0.5	10000.	210.0	104719.	65504.	52.6	9471.	3844.	70.7	10888.	4277.			
5	0.5	9000.	194.4	96287.	55759.	48.8	8767.	3356.	65.6	10103.	3981.			
6	0.5	1500.	184.5	90949.	56446.	46.3	8320.	3184.	62.4	9589.	3683.			
7	0.5	10000.	210.0	103489.	64374.	31.0	2251.	877.	42.4	2614.	989.			
8	0.5	9000.	194.4	95148.	58618.	30.0	2101.	803.	39.4	2435.	938.			
9	0.5	1500.	184.5	89867.	55365.	30.0	2020.	772.	37.5	2321.	894.			
10	0.5	10000.	210.0	103304.	64205.	30.0	684.	316.	30.0	684.	316.			
11	0.5	9000.	194.4	94977.	58448.	30.0	754.	334.	30.0	754.	334.			
12	0.5	1500.	184.5	89705.	55204.	30.0	808.	358.	30.0	808.	358.			
13	0.5	10000.	210.0	103304.	64205.	30.0	684.	316.	30.0	684.	316.			
14	0.5	9000.	194.4	94977.	58448.	30.0	754.	334.	30.0	754.	334.			
15	0.5	1500.	184.5	89705.	55204.	30.0	808.	358.	30.0	808.	358.			
16	0.6	10000.	210.0	102260.	63966.	78.3	26456.	10415.	105.0	28202.	11147.			
17	0.6	9000.	194.4	94057.	58387.	72.7	24884.	9546.	97.4	26639.	10250.			
18	0.6	1500.	184.5	88862.	55162.	69.0	23787.	9125.	92.6	25611.	9854.			
19	0.6	10000.	210.0	98752.	59747.	62.8	14540.	5808.	84.4	16042.	6460.			
20	0.6	9000.	194.4	90809.	55161.	58.3	13452.	5149.	79.3	15111.	5776.			
21	0.6	1500.	184.5	85780.	52106.	55.4	12760.	4884.	74.4	14502.	5544.			
22	0.6	10000.	210.0	96713.	56540.	42.5	4884.	1870.	57.4	5639.	2303.			
23	0.6	9000.	194.4	88922.	53314.	39.4	4529.	1734.	53.3	5231.	2218.			
24	0.6	1500.	184.5	83989.	50357.	37.4	4303.	1647.	50.7	4971.	1918.			
25	0.6	10000.	210.0	96136.	55946.	30.0	650.	301.	30.0	650.	301.			
26	0.6	9000.	194.4	88387.	52703.	30.0	716.	319.	30.0	716.	319.			
27	0.6	1500.	184.5	83481.	49778.	30.0	766.	341.	30.0	766.	341.			

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TABLE IV-54
DESIGN VMAX = 210. KNOTS

CONVENTIONAL			RIGID		DESIGN ALTITUDE, H3 = 20000. FT				RECIPROCATING - COMPOUND ENGINE			
WC = 1500000. LBS			H		VMAX		FUEL FLOW		VOLUME		WF+PL	
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO	W	FT.	KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	20000.	210.0	100847.	54292.	30.0	673.	316.	30.0	673.	316.	
2	1.0	10000.	178.4	84438.	33569.	30.0	830.	378.	30.0	830.	378.	
3	1.0	1500.	156.8	73320.	29149.	30.0	992.	451.	30.0	992.	451.	
4	0.5	20000.	210.0	98122.	51748.	55.3	10020.	3831.	74.4	11293.	4509.	
5	0.5	10000.	178.4	80502.	32007.	47.2	8512.	3360.	63.5	9810.	3947.	
6	0.5	1500.	156.8	69916.	27798.	41.6	7481.	2953.	56.0	8624.	3470.	
7	0.9	20000.	210.0	94923.	41712.	38.2	3613.	1509.	51.9	4178.	1695.	
8	0.9	10000.	178.4	79483.	31427.	32.6	3088.	1195.	44.3	3576.	1468.	
9	0.9	1500.	156.8	69021.	27291.	30.0	2737.	1059.	35.2	3164.	1299.	
10	0.9	20000.	210.0	94544.	38593.	30.0	643.	303.	30.0	643.	303.	
11	0.9	10000.	178.4	78161.	31260.	30.0	791.	361.	30.0	791.	361.	
12	0.9	1500.	156.8	68738.	27144.	30.0	942.	430.	30.0	942.	430.	
13	0.9	20000.	210.0	94544.	38593.	30.0	643.	303.	30.0	643.	303.	
14	0.9	10000.	178.4	79161.	31260.	30.0	791.	361.	30.0	791.	361.	
15	0.9	1500.	156.8	68738.	27144.	30.0	942.	430.	30.0	942.	430.	
16	0.8	20000.	210.0	94794.	51032.	82.4	27673.	11011.	110.5	29414.	11513.	
17	0.8	10000.	178.4	79455.	31603.	70.3	24319.	9586.	94.3	26081.	10324.	
18	0.8	1500.	156.8	69054.	27465.	62.0	21346.	8414.	83.1	23623.	9351.	
19	0.8	20000.	210.0	91409.	36048.	69.0	17376.	6777.	92.7	18716.	7419.	
20	0.8	10000.	178.4	76579.	30149.	58.9	14738.	5879.	79.1	16515.	6618.	
21	0.8	1500.	156.8	68527.	26192.	51.9	12934.	5159.	69.7	14894.	5968.	
22	0.8	20000.	210.0	89172.	34764.	52.6	8095.	3048.	70.8	9308.	3695.	
23	0.8	10000.	178.4	74675.	25288.	44.8	6382.	2687.	60.4	7936.	3209.	
24	0.8	1500.	156.8	64857.	25436.	39.5	6053.	2363.	53.3	6983.	2824.	
25	0.8	20000.	210.0	88083.	34262.	30.0	1597.	686.	39.6	1858.	776.	
26	0.8	10000.	178.4	73753.	28369.	30.0	1461.	625.	34.0	1612.	679.	
27	0.8	1500.	156.8	64044.	25069.	30.0	1440.	616.	30.0	1444.	658.	

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TABLE IV-55
DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

CONVENTIONAL RIGID

W0 = 250000. LBS		DESIGN ALTITUDE, H0 = 5000. FT					LS/WO		VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VWAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	L-C	5000.	140.0	12206.	5261.	30.0	381.	179.	40.0	381.	179.
2	L-C	3000.	135.5	11938.	5082.	30.0	391.	183.	30.0	391.	183.
3	L-C	1500.	132.9	11741.	4953.	30.0	399.	187.	30.0	399.	187.
4	C-5	5000.	140.0	11648.	5020.	36.6	1360.	568.	50.9	1590.	648.
5	C-5	3000.	135.9	11393.	4851.	35.6	1325.	556.	49.5	1550.	634.
6	C-9	1500.	132.9	11206.	4728.	34.8	1299.	547.	48.5	1520.	624.
7	0-9	5000.	140.0	11495.	4918.	30.0	552.	254.	35.4	627.	286.
8	C-5	3000.	135.5	11243.	4752.	30.0	551.	253.	34.5	617.	281.
9	0-9	1500.	132.9	11058.	4632.	30.0	550.	253.	33.9	609.	278.
10	C-5	5000.	140.0	11463.	4897.	30.0	370.	174.	30.0	370.	174.
11	C-5	3000.	135.9	11212.	4731.	30.0	379.	178.	30.0	379.	178.
12	C-5	1500.	132.9	11027.	4611.	30.0	387.	181.	30.0	387.	181.
13	0-9	5000.	140.0	11463.	4897.	30.0	370.	174.	30.0	370.	174.
14	C-5	3000.	135.9	11212.	4731.	30.0	379.	178.	30.0	379.	178.
15	0-9	1500.	132.9	11027.	4611.	30.0	387.	181.	30.0	387.	181.
16	0-8	5000.	140.0	11489.	4952.	54.5	3572.	1480.	73.9	4084.	1566.
17	C-8	3000.	135.9	11239.	4785.	52.9	3469.	1414.	71.8	3992.	1557.
18	0-8	1500.	132.9	11056.	4665.	51.8	3396.	1367.	70.3	3925.	1536.
19	0-8	5000.	140.0	11056.	4665.	44.5	2095.	810.	61.0	2434.	922.
20	C-8	3000.	135.9	10815.	4507.	43.3	2038.	792.	59.3	2368.	899.
21	C-8	1500.	132.9	10638.	4391.	42.3	1996.	779.	58.1	2320.	883.
22	0-8	5000.	140.0	10790.	4491.	31.9	929.	408.	45.3	1096.	472.
23	0-8	3000.	135.9	10553.	4336.	31.0	907.	400.	44.1	1071.	463.
24	C-8	1500.	132.9	10380.	4224.	30.3	891.	393.	43.2	1053.	456.
25	C-8	5000.	140.0	10690.	4424.	30.0	364.	171.	30.0	364.	171.
26	C-8	3000.	135.5	10455.	4272.	30.0	372.	174.	30.0	372.	174.
27	C-8	1500.	132.9	10283.	4162.	30.0	378.	177.	30.0	378.	177.

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TABLE IV-56
DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

CONVENTIONAL		RIGID		DESIGN ALTITUDE, H3 = 10000. FT		DESIGN VMAX = 140. KNOTS		LS/WO		VOLUME		WF+PL	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
LS/WO	W	H	VMAX	BHP	FUEL	V MIN	BHP	FUEL	V MAX	BHP	FUEL	W	FUEL
		FT.	KNOTS		LS/HR	KNOTS		LS/HR	KNOTS		LS/HR		LS/HR
1	1-C	10000.	140.0	11675.	4718.	30.0	373.	176.	30.0	373.	176.	45054.	45054.
2	1-C	5000.	129.6	11025.	4318.	30.0	299.	187.	30.0	399.	187.	51920.	51920.
3	1-C	1500.	123.0	10594.	4080.	30.0	418.	196.	30.0	418.	196.	58491.	58491.
4	1-C	10000.	140.0	11157.	4509.	37.5	1391.	586.	52.2	1626.	668.		
5	1-C	5000.	129.6	10537.	4127.	34.8	1301.	554.	48.5	1522.	632.		
6	1-C	1500.	123.0	10128.	3900.	33.1	1243.	533.	46.2	1456.	609.		
7	0.9	10000.	140.0	11007.	4414.	30.0	618.	283.	38.1	724.	328.		
8	0.9	5000.	129.6	10395.	4047.	30.0	605.	278.	35.7	690.	314.		
9	0.9	1500.	123.0	9990.	3826.	30.0	602.	276.	34.1	668.	304.		
10	0.9	10000.	140.0	10962.	4386.	30.0	363.	171.	30.0	363.	171.		
11	0.9	5000.	129.6	10352.	4024.	30.0	387.	181.	30.0	387.	181.		
12	0.9	1500.	123.0	9949.	3807.	30.0	405.	190.	30.0	405.	190.		
13	0.9	10000.	140.0	10962.	4386.	30.0	363.	171.	30.0	363.	171.		
14	0.9	5000.	129.6	10352.	4024.	30.0	387.	181.	30.0	387.	181.		
15	0.9	1500.	123.0	9949.	3807.	30.0	405.	190.	30.0	405.	190.		
16	0.8	10000.	140.0	11061.	4470.	55.9	3662.	1474.	75.8	4165.	1803.		
17	0.8	5000.	129.6	10451.	4094.	51.8	3407.	1318.	70.3	3929.	1648.		
18	0.8	1500.	123.0	10048.	3871.	49.2	3233.	1233.	66.9	3741.	1525.		
19	0.8	10000.	140.0	10640.	4206.	46.7	2274.	878.	63.9	2439.	999.		
20	0.8	5000.	129.6	10051.	3872.	43.3	2116.	828.	59.3	2458.	938.		
21	0.8	1500.	123.0	9661.	3681.	41.1	2016.	796.	56.4	2343.	900.		
22	0.8	10000.	140.0	10364.	4045.	35.4	1141.	494.	49.7	1339.	567.		
23	0.8	5000.	129.6	9788.	3739.	32.9	1070.	467.	46.3	1257.	537.		
24	0.8	1500.	123.0	9408.	3565.	31.2	1044.	449.	44.1	1205.	518.		
25	0.8	10000.	140.0	10231.	3971.	30.0	423.	198.	31.9	448.	209.		
26	0.8	5000.	129.6	9662.	3681.	30.0	435.	203.	30.0	435.	203.		
27	0.8	1500.	123.0	9285.	3510.	30.0	446.	208.	30.0	446.	208.		

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TABLE IV-57
DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

CONVENTIONAL		RIGID		DESIGN ALTITUDE, H3 = 20000. FT		DESIGN VMAX = 140. KNOTS		TABLE IV-57		AIR-COOLED DIESEL ENGINE	
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO	W0	H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	20000.	140.0	10040.	4176.	30.0	358.	169.	30.0	358.	169.
2	1.0	10000.	118.9	9412.	3558.	30.0	411.	193.	30.0	411.	193.
3	1.0	1500.	104.5	8502.	3209.	30.0	465.	217.	30.0	465.	217.
4	0.9	20000.	140.0	10203.	4005.	39.5	1461.	607.	54.3	1705.	691.
5	0.9	10000.	118.9	9028.	3413.	33.7	1267.	538.	47.1	1484.	615.
6	0.9	1500.	104.5	8158.	3079.	30.0	1135.	490.	41.7	1332.	502.
7	0.9	20000.	140.0	10078.	3935.	31.7	868.	386.	45.2	1027.	449.
8	0.9	10000.	118.9	8916.	3369.	30.0	775.	348.	39.0	910.	403.
9	0.9	1500.	104.5	8055.	3042.	30.0	740.	334.	34.7	830.	371.
10	0.9	20000.	140.0	10006.	3894.	30.0	462.	215.	34.1	514.	238.
11	0.9	10000.	118.9	8851.	3343.	30.0	480.	223.	30.0	481.	223.
12	0.9	1500.	104.5	7996.	3020.	30.0	512.	237.	30.0	512.	237.
13	0.9	20000.	140.0	9986.	3883.	30.0	348.	164.	30.0	348.	164.
14	0.9	10000.	118.9	8833.	3336.	30.0	398.	186.	30.0	398.	186.
15	0.9	1500.	104.5	7979.	3014.	30.0	449.	209.	30.0	449.	209.
16	0.8	20000.	140.0	10243.	4020.	58.9	3863.	1627.	79.8	4343.	1683.
17	0.8	10000.	118.9	9073.	3430.	50.2	3301.	1277.	68.2	3819.	1598.
18	0.8	1500.	104.5	8205.	3097.	44.2	2916.	1101.	60.2	3377.	1319.
19	0.8	20000.	140.0	9885.	3821.	52.0	2769.	1045.	70.9	3201.	1224.
20	0.8	10000.	118.9	8752.	3304.	44.3	2375.	907.	60.6	2755.	1043.
21	0.8	1500.	104.5	7912.	2590.	39.1	2105.	821.	53.6	2445.	931.
22	0.8	20000.	140.0	9613.	3677.	44.1	1819.	726.	60.8	2107.	821.
23	0.8	10000.	118.9	8508.	3208.	37.7	1563.	643.	52.1	1823.	730.
24	0.8	1500.	104.5	7688.	2513.	33.2	1394.	584.	46.1	1629.	655.
25	0.8	20000.	140.0	9426.	3591.	34.7	1010.	462.	49.1	1197.	510.
26	0.8	10000.	118.9	8340.	3146.	30.0	886.	393.	42.3	1047.	457.
27	0.8	1500.	104.5	7535.	2860.	30.0	819.	366.	37.5	957.	419.

11/20/67

CONVENTIONAL RIGID
 TABLE IV-58
 DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

W0 = 625000. LBS

DESIGN ALTITUDE, H3 = 5000. FT

	1	2	3	4	5	6	7	8	9	10	11	12
	LS/WO	H	VPAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	LS/WO	V(MAX RGE)	BHP	FUEL
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR		KNOTS		LBS/HR
1	1.0	5000.	140.0	21179.	9128.	30.0	515.	239.	1.0	30.0	515.	239.
2	1.0	3000.	135.9	20713.	8818.	30.0	532.	246.	0.9	30.0	532.	246.
3	1.0	1500.	132.9	20371.	8594.	30.0	546.	252.	0.8	30.0	546.	252.
4	0.9	5000.	140.0	20498.	8835.	43.5	3509.	1385.		59.1	4058.	1739.
5	0.9	3000.	135.9	20049.	8536.	42.3	3409.	1327.		57.4	3943.	1664.
6	0.9	1500.	132.9	19720.	8319.	41.4	3336.	1287.		56.2	3860.	1609.
7	0.9	5000.	140.0	19870.	8418.	30.0	496.	230.		30.0	496.	230.
8	0.9	3000.	135.9	19433.	8133.	30.0	512.	237.		30.0	512.	237.
9	0.9	1500.	132.9	19113.	7921.	30.0	525.	243.		30.0	525.	243.
10	0.9	5000.	140.0	19870.	8418.	30.0	496.	230.		30.0	496.	230.
11	0.9	3000.	135.9	19433.	8133.	30.0	512.	237.		30.0	512.	237.
12	0.9	1500.	132.9	19113.	7921.	30.0	524.	242.		30.0	524.	242.
13	0.9	5000.	140.0	19870.	8418.	30.0	496.	230.		30.0	496.	230.
14	0.9	3000.	135.9	19433.	8133.	30.0	512.	237.		30.0	512.	237.
15	0.9	1500.	132.9	19113.	7921.	30.0	524.	242.		30.0	524.	242.
16	0.8	5000.	140.0	21221.	5146.	64.8	9815.	3730.		87.2	13751.	4075.
17	0.8	3000.	135.9	20761.	8840.	63.0	9523.	3599.		84.7	10508.	3992.
18	0.8	1500.	132.9	20424.	8619.	61.6	9313.	3517.		82.9	10331.	3931.
19	0.8	5000.	140.0	19155.	7790.	44.8	3533.	1376.		60.7	4085.	1724.
20	0.8	3000.	135.9	18735.	7523.	43.5	3431.	1320.		59.0	3969.	1649.
21	0.8	1500.	132.9	18428.	7330.	42.5	3359.	1283.		57.7	3885.	1593.
22	0.8	5000.	140.0	18505.	7378.	30.0	475.	221.		30.0	475.	221.
23	0.8	3000.	135.9	18098.	7126.	30.0	490.	228.		30.0	490.	228.
24	0.8	1500.	132.9	17800.	6955.	30.0	502.	233.		30.0	502.	233.
25	0.8	5000.	140.0	18505.	7378.	30.0	475.	221.		30.0	475.	221.
26	0.8	3000.	135.9	18098.	7126.	30.0	490.	228.		30.0	490.	228.
27	0.8	1500.	132.9	17800.	6955.	30.0	502.	233.		30.0	502.	233.

TABLE IV-59
DESIGN VMAX = 140. KNOTS

CONVENTIONAL		RIGID		DESIGN VMAX = 140. KNOTS		AIR-COOLED DIESEL ENGINE							
WC = 625000. LBS		DESIGN ALTITUDE, H3 = 10000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1-C	10000.	140-C	20291.	8200.	30.0	502.	234.	30.0	502.	234.		
2	1-0	5000.	129.6	19159.	7503.	30.0	546.	253.	30.0	546.	253.		
3	1-0	1500.	123.0	18412.	7089.	30.0	580.	268.	30.0	580.	268.		
4	1-5	10000.	140-C	19695.	7960.	44.6	3600.	1390.	60.5	4163.	1737.		
5	1-5	5000.	129.6	18601.	7285.	41.4	3342.	1266.	56.2	3867.	1546.		
6	1-9	1500.	123.0	17879.	6885.	39.3	3178.	1199.	53.4	3678.	1434.		
7	1-5	10000.	140-C	19038.	7546.	30.0	501.	233.	30.0	501.	233.		
8	1-9	5000.	129.6	17976.	6938.	30.0	540.	250.	30.0	540.	250.		
9	1-5	1500.	123.0	17275.	6587.	30.0	570.	263.	30.0	570.	263.		
10	1-5	10000.	140-C	19034.	7544.	30.0	483.	225.	30.0	483.	225.		
11	1-9	5000.	129.6	17973.	6937.	30.0	525.	244.	30.0	525.	244.		
12	1-5	1500.	123.0	17272.	6586.	30.0	556.	257.	30.0	556.	257.		
13	1-5	10000.	140-C	19034.	7544.	30.0	483.	225.	30.0	483.	225.		
14	1-9	5000.	129.6	17973.	6937.	30.0	525.	244.	30.0	525.	244.		
15	1-5	1500.	123.0	17272.	6586.	30.0	556.	257.	30.0	556.	257.		
16	1-8	10000.	140.0	20582.	8318.	66.5	10077.	3805.	89.4	10971.	4194.		
17	1-8	5000.	129.6	19453.	7621.	61.6	9328.	3521.	82.9	10347.	3911.		
18	1-8	1500.	123.0	18707.	7208.	58.6	8852.	3351.	78.8	9938.	3750.		
19	1-8	10000.	140.0	18499.	7094.	47.4	3959.	1565.	64.2	4576.	1964.		
20	0-8	5000.	129.6	17473.	6619.	44.0	3674.	1406.	59.6	4248.	1748.		
21	1-1	1500.	123.0	16795.	6341.	41.8	3492.	1323.	56.7	4040.	1615.		
22	1-8	10000.	140.0	17729.	6735.	30.0	492.	230.	30.0	492.	230.		
23	0-8	5000.	129.6	16740.	6320.	30.0	527.	245.	30.0	527.	245.		
24	1-8	1500.	123.0	16088.	6066.	30.0	554.	257.	30.0	554.	257.		
25	1-8	10000.	140.0	17724.	6733.	30.0	464.	217.	30.0	464.	217.		
26	0-8	5000.	129.6	16735.	6318.	30.0	502.	234.	30.0	502.	234.		
27	1-8	1500.	123.0	16083.	6064.	30.0	532.	247.	30.0	532.	247.		

11/28/c7

CONVENTIONAL

TABLE IV-60
DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

CONVENTIONAL			RIGID			DESIGN ALTITUDE, H3 = 20000. FT									
WC = 625000. LBS			H												
1	2	3	4	5	6	7	8	9	10	11	12				
LS/WC			VMAX	BHP	FUEL	V (MIN BHP)	BHP	FUEL	V (MAX RGE)	BHP	FUEL	LS/WC	VOLUME	WF+PL	
			KNOTS		FLOW	KNOTS		FLOW	KNOTS		FLOW				
					LBS/HR			LBS/HR			LBS/HR				
1	1.0	WC	20000.	18546.	7279.	30.0	476.	222.	30.0	476.	222.	1.0	19744192.	179753.	
2	1.0	WC	10000.	16402.	6200.	30.0	569.	263.	30.0	569.	263.	0.9	17769760.	192268.	
3	1.0	WC	1500.	14814.	5592.	30.0	663.	304.	30.0	663.	304.	0.8	15795354.	201780.	
4	0.5	WC	20000.	18129.	7116.	47.0	3800.	1531.	63.7	4393.	1718.				
5	0.5	WC	10000.	16044.	6064.	40.1	3247.	1230.	54.4	3758.	1505.				
6	0.5	WC	1500.	14498.	5472.	35.3	2869.	1083.	48.1	3323.	1265.				
7	0.9	W1	20000.	17432.	6728.	30.0	682.	311.	32.6	733.	333.				
8	0.9	W1	10000.	15418.	5819.	30.0	706.	321.	30.0	706.	321.				
9	0.9	W1	1500.	13926.	5264.	30.0	759.	343.	30.0	759.	343.				
10	0.9	W2	20000.	17393.	6707.	30.0	459.	214.	30.0	459.	214.				
11	0.5	W2	10000.	15383.	5805.	30.0	546.	252.	30.0	546.	252.				
12	0.5	W2	1500.	13894.	5252.	30.0	634.	291.	30.0	634.	291.				
13	0.9	W3	20000.	17393.	6707.	30.0	459.	214.	30.0	459.	214.				
14	0.5	W3	10000.	15383.	5805.	30.0	546.	252.	30.0	546.	252.				
15	0.5	W3	1500.	13894.	5252.	30.0	634.	291.	30.0	634.	291.				
16	0.8	W0	20000.	19377.	7605.	70.0	10658.	4057.	94.1	11448.	4344.				
17	0.8	W0	10000.	17179.	6496.	59.7	9052.	3420.	80.3	10118.	3922.				
18	0.8	W0	1500.	15547.	5857.	52.6	7954.	3046.	72.9	9146.	3454.				
19	0.8	W1	20000.	17324.	6562.	53.5	5063.	1953.	72.3	5806.	2200.				
20	0.8	W1	10000.	15336.	5791.	45.6	4316.	1802.	61.9	4987.	1929.				
21	0.8	W1	1500.	13863.	5251.	40.2	3806.	1482.	54.5	4400.	1856.				
22	0.8	W2	20000.	16305.	6153.	30.0	1113.	489.	41.9	1307.	563.				
23	0.8	W2	10000.	14425.	5469.	30.0	1007.	447.	36.0	1147.	502.				
24	0.8	W2	1500.	13031.	4916.	30.0	979.	436.	32.0	1037.	459.				
25	0.8	W3	20000.	16190.	6106.	30.0	441.	207.	30.0	441.	207.				
26	0.8	W3	10000.	14319.	5433.	30.0	522.	243.	30.0	522.	243.				
27	0.8	W3	1500.	12933.	4878.	30.0	604.	279.	30.0	604.	279.				

11/28/07

CONVENTIONAL RIGID AIR-COOLED DIESEL ENGINE

TABLE IV-61
DESIGN VMAX = 140. KNOTS

WC = 1500000. LBS DESIGN ALTITUDE, H3 = 5000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WC	H	VMAX	BHP	FUEL FLOW	V(MIN BHP)	BHP	FUEL FLOW	VMAX	BHP	FUEL FLOW	WF, PL
	FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS			
1	1.0	5000.	140.0	36079.	15550.	30.0	738.	30.0	733.	336.	749465.
2	1.0	3000.	135.9	35285.	15021.	30.0	767.	30.0	767.	348.	746395.
3	1.0	1500.	132.9	34702.	14639.	30.0	790.	30.0	790.	358.	737643.
4	0.5	5000.	140.0	35848.	15450.	51.3	9222.	69.1	10626.	4059.	
5	0.5	3000.	135.9	35064.	14929.	49.8	8948.	67.1	10311.	3915.	
6	0.5	1500.	132.9	34489.	14551.	48.8	8751.	65.6	10084.	3812.	
7	0.9	5000.	140.0	33831.	14120.	30.0	704.	30.0	704.	322.	
8	0.9	3000.	135.9	33086.	13631.	30.0	732.	30.0	732.	333.	
9	0.9	1500.	132.9	32540.	13277.	30.0	753.	30.0	753.	342.	
10	0.9	5000.	140.0	33831.	14120.	30.0	704.	30.0	704.	322.	
11	0.9	3000.	135.9	33086.	13631.	30.0	732.	30.0	732.	333.	
12	0.9	1500.	132.9	32540.	13277.	30.0	753.	30.0	753.	342.	
13	0.9	5000.	140.0	33831.	14120.	30.0	704.	30.0	704.	322.	
14	0.9	3000.	135.9	33086.	13631.	30.0	732.	30.0	732.	333.	
15	0.9	1500.	132.9	32540.	13277.	30.0	753.	30.0	753.	342.	
16	0.8	5000.	140.0	40211.	17331.	76.5	25896.	102.5	27644.	10429.	
17	0.8	3000.	135.9	39349.	16757.	74.2	25284.	99.6	27035.	10207.	
18	0.8	1500.	132.9	38717.	16342.	72.6	24838.	97.4	26590.	10045.	
19	0.8	5000.	140.0	32781.	12655.	46.6	6579.	62.9	7588.	2981.	
20	0.8	3000.	135.9	32062.	12271.	45.3	6386.	61.1	7365.	2857.	
21	0.8	1500.	132.9	31536.	12029.	44.3	6247.	59.7	7205.	2768.	
22	0.8	5000.	140.0	31485.	12005.	30.0	669.	30.0	669.	307.	
23	0.8	3000.	135.9	30792.	11689.	30.0	695.	30.0	695.	317.	
24	0.8	1500.	132.9	30284.	11457.	30.0	715.	30.0	715.	326.	
25	0.8	5000.	140.0	31485.	12005.	30.0	669.	30.0	669.	307.	
26	0.8	3000.	135.9	30792.	11688.	30.0	695.	30.0	695.	317.	
27	0.8	1500.	132.9	30284.	11457.	30.0	715.	30.0	715.	326.	

11/28/67

TABLE IV-62
DESIGN VMAX = 140. KNOTS

AIR-COOLED DIESEL ENGINE

CONVENTIONAL			RIGID		DESIGN ALTITUDE, H3 = 10000. FT										VOLUME				WF+PL	
W0 = 1500000. LBS			H		DESIGN ALTITUDE, H3 = 10000. FT										V(MAX RGE)				FUEL	
LS/WO			FT.		V(MIN BHP)										KNOTS				LBS/HR	
1			3		7										8				9	
2			4		6										5				10	
LS/WO			VMAX		FUEL										BHP				FUEL	
1			KNOTS		FLOW										KNOTS				LBS/HR	
2			KNOTS		LBS/HR										KNOTS				LBS/HR	
3			KNOTS		KNOTS										KNOTS				LBS/HR	
4			KNOTS		KNOTS										KNOTS				LBS/HR	
5			KNOTS		KNOTS										KNOTS				LBS/HR	
6			KNOTS		KNOTS										KNOTS				LBS/HR	
7			KNOTS		KNOTS										KNOTS				LBS/HR	
8			KNOTS		KNOTS										KNOTS				LBS/HR	
9			KNOTS		KNOTS										KNOTS				LBS/HR	
10			KNOTS		KNOTS										KNOTS				LBS/HR	
11			KNOTS		KNOTS										KNOTS				LBS/HR	
12			KNOTS		KNOTS										KNOTS				LBS/HR	
13			KNOTS		KNOTS										KNOTS				LBS/HR	
14			KNOTS		KNOTS										KNOTS				LBS/HR	
15			KNOTS		KNOTS										KNOTS				LBS/HR	
16			KNOTS		KNOTS										KNOTS				LBS/HR	
17			KNOTS		KNOTS										KNOTS				LBS/HR	
18			KNOTS		KNOTS										KNOTS				LBS/HR	
19			KNOTS		KNOTS										KNOTS				LBS/HR	
20			KNOTS		KNOTS										KNOTS				LBS/HR	
21			KNOTS		KNOTS										KNOTS				LBS/HR	
22			KNOTS		KNOTS										KNOTS				LBS/HR	
23			KNOTS		KNOTS										KNOTS				LBS/HR	
24			KNOTS		KNOTS										KNOTS				LBS/HR	
25			KNOTS		KNOTS										KNOTS				LBS/HR	
26			KNOTS		KNOTS										KNOTS				LBS/HR	
27			KNOTS		KNOTS										KNOTS				LBS/HR	

CONVENTIONAL RIGID

AIR-COOLED DIESEL ENGINE

DESIGN ALTITUDE, H3 = 20000. FT											
WC = 1500000. LBS			DESIGN ALTITUDE, H3 = 20000. FT						WF+PL		
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	20000.	140.0	31674.	12432.	30.0	673.	309.	30.0	673.	309.
2	1.0	10000.	118.9	28010.	10587.	30.0	830.	376.	30.0	830.	376.
3	1.0	1500.	104.5	25297.	9549.	30.0	992.	442.	30.0	992.	442.
4	0.9	20000.	140.0	32060.	12583.	55.3	10020.	3779.	74.4	11393.	4339.
5	0.9	10000.	118.9	28383.	10729.	47.2	8512.	3243.	63.5	9817.	3700.
6	0.9	1500.	104.5	25656.	9684.	41.6	7481.	2858.	56.0	8624.	3282.
7	0.9	20000.	140.0	29693.	11328.	30.0	643.	296.	30.0	643.	296.
8	0.9	10000.	118.9	26259.	9903.	30.0	791.	359.	30.0	791.	359.
9	0.9	1500.	104.5	23715.	8549.	30.0	942.	422.	30.0	942.	422.
10	0.9	20000.	140.0	29693.	11328.	30.0	643.	296.	30.0	643.	296.
11	0.9	10000.	118.9	26259.	9903.	30.0	791.	359.	30.0	791.	359.
12	0.9	1500.	104.5	23715.	8949.	30.0	942.	422.	30.0	942.	422.
13	0.9	20000.	140.0	29693.	11328.	30.0	643.	296.	30.0	643.	296.
14	0.9	10000.	118.9	26259.	9903.	30.0	791.	359.	30.0	791.	359.
15	0.9	1500.	104.5	23715.	8949.	30.0	942.	422.	30.0	942.	422.
16	0.8	20000.	140.0	37867.	14862.	82.4	27673.	10435.	110.5	29414.	11114.
17	0.8	10000.	118.9	33621.	12717.	70.3	24319.	9168.	94.3	26081.	9855.
18	0.8	1500.	104.5	30463.	11495.	62.0	21346.	8055.	83.1	23623.	8915.
19	0.8	20000.	140.0	30013.	11332.	56.5	9899.	3739.	76.0	11202.	4237.
20	0.8	10000.	118.9	26573.	10035.	48.2	8409.	3300.	64.9	9692.	3663.
21	0.8	1500.	104.5	24022.	9061.	42.5	7390.	2793.	57.2	8521.	3270.
22	0.8	20000.	140.0	27626.	10418.	30.0	612.	284.	30.0	612.	284.
23	0.8	10000.	118.9	24431.	9212.	30.0	750.	343.	30.0	750.	343.
24	0.8	1500.	104.5	22065.	8361.	30.0	891.	403.	30.0	891.	403.
25	0.8	20000.	140.0	27626.	10418.	30.0	612.	284.	30.0	612.	284.
26	0.8	10000.	118.9	24431.	9212.	30.0	750.	343.	30.0	750.	343.
27	0.8	1500.	104.5	22065.	8361.	30.0	891.	403.	30.0	891.	403.

3-LOBED DYNASTAT NON-RIGID

TABLE IV-64
DESIGN VMAX = 70. KNOTS

WC = 10000. LBS DESIGN ALTITUDE, H3 = 5000. FT

3-LOBED DYNASTAT NON-RIGID				DESIGN ALTITUDE, H3 = 5000. FT			RECIPROCATING - COMPOUND ENGINE					
WC = 100000. LBS				DESIGN VMAX = 70. KNOTS			DESIGN VMAX = 70. KNOTS					
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WC	H	FT.	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RCE)	BHP	WF+PL	
			KNOTS		FLOW	KNOTS		FLOW	KNOTS		FUEL	
					LBS/HR			LBS/HR			FLOW	
											LBS/HR	
1	1-C	5000.	70.0	1917.	1267.	30.0	371.	145.	30.0	371.	145.	
2	1-C	3000.	67.9	1855.	1226.	30.0	380.	149.	30.0	380.	149.	
3	1-C	1500.	66.4	1810.	1196.	30.0	388.	152.	30.0	388.	152.	
4	C-8	5000.	70.0	1960.	1296.	33.5	990.	381.	47.4	1166.	460.	
5	C-8	3000.	67.9	1898.	1254.	32.5	966.	372.	46.1	1139.	450.	
6	C-8	1500.	66.4	1853.	1225.	31.8	949.	365.	45.2	1119.	442.	
7	C-8	5000.	70.0	1953.	1310.	30.0	520.	201.	36.4	600.	238.	
8	C-8	3000.	67.9	1897.	1074.	30.0	518.	200.	35.4	590.	234.	
9	C-8	1500.	66.4	1856.	1048.	30.0	517.	200.	34.8	583.	231.	
10	C-8	5000.	70.0	1981.	1036.	30.0	350.	139.	30.0	350.	139.	
11	C-8	3000.	67.9	1826.	1002.	30.0	358.	143.	30.0	358.	143.	
12	C-8	1500.	66.4	1887.	978.	30.0	365.	145.	30.0	365.	145.	
13	C-8	5000.	70.0	1981.	1035.	30.0	350.	139.	30.0	350.	139.	
14	C-8	3000.	67.9	1826.	1002.	30.0	358.	142.	30.0	358.	142.	
15	C-8	1500.	66.4	1887.	978.	30.0	364.	145.	30.0	364.	145.	
16	C-6	5000.	70.0	2776.	1835.	52.7	2632.	1709.	71.9	2026.	839.	
17	C-6	3000.	67.9	2690.	1778.	51.2	2558.	1661.	69.8	1972.	817.	
18	C-6	1500.	66.4	2628.	1737.	50.1	2505.	1627.	68.4	1933.	801.	
19	C-6	5000.	70.0	2751.	1842.	44.9	2739.	1739.	61.9	2026.	839.	
20	C-6	3000.	67.9	2683.	1806.	43.6	2692.	1692.	60.1	1972.	817.	
21	C-6	1500.	66.4	2635.	1737.	42.6	2659.	1659.	58.9	1933.	801.	
22	C-6	5000.	70.0	2718.	1842.	35.5	2739.	1739.	50.3	2026.	839.	
23	C-6	3000.	67.9	2683.	1806.	34.5	2692.	1692.	49.0	1972.	817.	
24	C-6	1500.	66.4	2635.	1737.	33.8	2659.	1659.	48.0	1933.	801.	
25	C-6	5000.	70.0	2718.	1842.	35.5	2739.	1739.	50.3	2026.	839.	
26	C-6	3000.	67.9	2683.	1806.	34.5	2692.	1692.	49.0	1972.	817.	
27	C-6	1500.	66.4	2635.	1737.	33.8	2659.	1659.	48.0	1933.	801.	
28	C-6	5000.	70.0	2718.	1842.	35.5	2739.	1739.	50.3	2026.	839.	
29	C-6	3000.	67.9	2683.	1806.	34.5	2692.	1692.	49.0	1972.	817.	
30	C-6	1500.	66.4	2635.	1737.	33.8	2659.	1659.	48.0	1933.	801.	

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3-LUBED DYNASTAT NON-RIGID
TABLE IV-65
DESIGN VMAX = 70. KNOTS

			RECIPROCATING - COMPOUND ENGINE											
WC = 100000. LBS			DESIGN ALTITUDE, H3 = 10000. FT											
1	2	3	4	5	6	7	8	9	10	11	12			
LS/WC		H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	VMAX RGE)	BHP	FUEL	WF+PL		
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR			
1	1.0	10000.	70.0	1834.	1147.	30.0	364.	149.	30.0	364.	149.	32481.		
2	1.0	5000.	64.8	1685.	1046.	30.0	387.	151.	30.0	387.	151.	38466.		
3	1.0	1500.	61.5	1591.	988.	30.0	406.	158.	30.0	406.	158.	41442.		
4	0.8	10000.	70.0	1901.	1189.	34.3	1011.	386.	48.6	1191.	454.			
5	0.8	5000.	64.8	1750.	1086.	31.8	949.	364.	45.2	1120.	435.			
6	0.8	1500.	61.5	1653.	1027.	30.3	910.	349.	43.1	1076.	418.			
7	0.8	10000.	70.0	1686.	807.	30.0	529.	200.	37.4	617.	236.			
8	0.8	5000.	64.8	1550.	785.	30.0	523.	202.	35.0	591.	232.			
9	0.8	1500.	61.5	1464.	741.	30.0	523.	202.	33.5	574.	226.			
10	0.8	10000.	70.0	1607.	652.	30.0	344.	144.	30.0	344.	144.			
11	0.8	5000.	64.8	1477.	614.	30.0	365.	145.	30.0	365.	145.			
12	0.8	1500.	61.5	1395.	579.	30.0	381.	151.	30.0	381.	151.			
13	0.6	10000.	70.0	1607.	652.	30.0	343.	143.	30.0	343.	143.			
14	0.6	5000.	64.8	1477.	613.	30.0	364.	145.	30.0	364.	145.			
15	0.6	1500.	61.5	1395.	579.	30.0	380.	151.	30.0	380.	151.			
16	0.6	10000.	70.0	2784.	1741.	54.0	2697.	1639.	73.7	2098.	822.			
17	0.6	5000.	64.8	2568.	1597.	50.1	2507.	1536.	68.4	1958.	782.			
18	0.6	1500.	61.5	2432.	1512.	47.6	2387.	1463.	65.1	1869.	746.			
19	0.6	10000.	70.0	2140.	841.	46.2	1802.	689.	63.7	2098.	822.			
20	0.6	5000.	64.8	1973.	788.	42.9	1680.	655.	59.2	1958.	782.			
21	0.6	1500.	61.5	1866.	745.	40.8	1603.	625.	56.4	1869.	746.			
22	0.6	10000.	70.0	1688.	643.	37.0	1047.	410.	52.2	1232.	493.			
23	0.6	5000.	64.8	1554.	599.	34.3	983.	392.	48.6	1158.	452.			
24	0.6	1500.	61.5	1469.	567.	32.6	942.	376.	46.3	1112.	434.			
25	0.6	10000.	70.0	1428.	551.	30.0	486.	204.	38.5	576.	234.			
26	0.6	5000.	64.8	1313.	502.	30.0	480.	195.	36.1	553.	218.			
27	0.6	1500.	61.5	1240.	474.	30.0	480.	194.	34.6	538.	212.			

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3-LOBED DYNASTAT NON-FIG13

TABLE IV-66
DESIGN V_{MAX} = 70. KNOTS

DESIGN ALTITUDE, H3 = 20000. FT										RECIPROCATING - COMPOUND ENGINE				
DESIGN VMAX = 70.0 KNOTS														
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3-LUBE DYNASTAI NON-RIGID

TABLE IV-67
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

WG = 25000C. LBS

DESIGN ALTITUDE, H3 = 5000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/MC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1 1.0	W0	5000.	70.0	3310.	2188.	30.0	496.	204.	30.0	496.	204.
2 1.0	W0	3000.	67.9	3203.	2117.	30.0	512.	210.	30.0	512.	210.
3 1.0	W0	1500.	66.4	3125.	2066.	30.0	524.	215.	30.0	524.	215.
4 C.6	W0	5000.	70.0	3844.	2541.	39.9	2448.	974.	54.6	2842.	1185.
5 C.6	W0	3000.	67.9	3722.	2460.	38.8	2380.	947.	53.0	2763.	1152.
6 C.6	W0	1500.	66.4	3634.	2402.	37.9	2331.	927.	51.9	2707.	1129.
7 C.6	W1	5000.	70.0	2976.	1509.	30.0	647.	260.	31.6	680.	271.
8 C.6	W1	3000.	67.9	2880.	1519.	30.0	650.	262.	30.8	667.	266.
9 C.6	W1	1500.	66.4	2810.	1482.	30.0	653.	263.	30.2	658.	262.
10 C.6	W2	5000.	70.0	2895.	1256.	30.0	459.	195.	30.0	459.	195.
11 C.6	W2	3000.	67.9	2801.	1215.	30.0	473.	201.	30.0	473.	201.
12 C.6	W2	1500.	66.4	2734.	1186.	30.0	484.	205.	30.0	484.	205.
13 C.6	W3	5000.	70.0	2895.	1256.	30.0	459.	195.	30.0	459.	195.
14 C.6	W3	3000.	67.9	2801.	1215.	30.0	473.	201.	30.0	473.	201.
15 C.6	W3	1500.	66.4	2734.	1186.	30.0	484.	205.	30.0	484.	205.
16 C.6	W0	5000.	70.0	7037.	4651.	62.9	7116.	4719.	84.8		
17 C.6	W0	3000.	67.9	6822.	4509.	61.1	6906.	4580.	82.4		
18 C.6	W0	1500.	66.4	6687.	4407.	59.7	6754.	4480.	80.6		
19 C.6	W1	5000.	70.0	4290.	1703.	49.7	3726.	1438.	67.4	4310.	1712.
20 C.6	W1	3000.	67.9	4156.	1650.	48.2	3619.	1396.	65.5	4187.	1663.
21 C.6	W1	1500.	66.4	4059.	1612.	47.2	3542.	1367.	64.1	4099.	1628.
22 C.6	W2	5000.	70.0	2771.	1080.	31.8	1190.	479.	44.6	1396.	543.
23 C.6	W2	3000.	67.9	2682.	1046.	30.9	1160.	467.	43.3	1362.	530.
24 C.6	W2	1500.	66.4	2618.	1021.	30.2	1138.	458.	42.5	1337.	520.
25 C.6	W3	5000.	70.0	2438.	985.	30.0	418.	188.	30.0	418.	188.
26 C.6	W3	3000.	67.9	2359.	953.	30.0	430.	194.	30.0	430.	194.
27 C.6	W3	1500.	66.4	2302.	930.	30.0	439.	198.	30.0	439.	198.

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3-LOBED DYNASTAT JUVENILE

TABLE IV-68
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 10000. FT

WC = 250000. LBS

1	2	3	4	5	6	7	8	9	10	11	12
LS/WC		H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL LBS/HR
1 1.0	WC	10000.	70.0	3172.	1984.	30.0	484.	208.	30.0	484.	208.
2 1.0	WC	5000.	64.8	2915.	1809.	30.0	525.	214.	30.0	525.	214.
3 1.0	WC	1500.	61.5	2753.	1758.	30.0	556.	227.	30.0	556.	227.
4 0.8	WC	10000.	70.0	3773.	2360.	40.9	2510.	966.	55.9	2912.	1145.
5 0.8	WC	5000.	64.8	3474.	2158.	37.9	2335.	916.	51.9	2711.	1084.
6 0.8	WC	1500.	61.5	3285.	2041.	36.1	2223.	872.	49.4	2583.	1033.
7 0.8	WC	10000.	70.0	2874.	1128.	30.0	682.	285.	33.4	746.	306.
8 0.8	WC	5000.	64.8	2642.	1034.	30.0	694.	275.	31.2	710.	283.
9 0.8	WC	1500.	61.5	2495.	996.	30.0	692.	278.	30.0	692.	276.
10 0.8	WC	10000.	70.0	2774.	1082.	30.0	448.	199.	30.0	448.	199.
11 0.8	WC	5000.	64.8	2549.	1014.	30.0	484.	205.	30.0	484.	205.
12 0.8	WC	1500.	61.5	2407.	958.	30.0	511.	217.	30.0	511.	217.
13 0.8	WC	10000.	70.0	2774.	1082.	30.0	448.	199.	30.0	448.	199.
14 0.8	WC	5000.	64.8	2549.	1014.	30.0	484.	205.	30.0	484.	205.
15 0.8	WC	1500.	61.5	2407.	958.	30.0	511.	217.	30.0	511.	217.
16 0.6	WC	10000.	70.0	7176.	4489.	64.5	7303.	4607.	86.9	4533.	1730.
17 0.6	WC	5000.	64.8	6628.	4125.	59.8	6764.	4263.	80.7	4208.	1633.
18 0.6	WC	1500.	61.5	6280.	3508.	56.8	6421.	4047.	76.7	4047.	1633.
19 0.6	WC	10000.	70.0	4355.	1659.	51.4	3920.	1491.	69.7	4533.	1730.
20 0.6	WC	5000.	64.8	4016.	1549.	47.6	3637.	1396.	64.7	4208.	1633.
21 0.6	WC	1500.	61.5	3801.	1466.	45.3	3458.	1327.	61.5	4208.	1633.
22 0.6	WC	10000.	70.0	2747.	1134.	34.0	1348.	558.	47.4	1577.	632.
23 0.6	WC	5000.	64.8	2528.	1009.	31.5	1261.	509.	44.1	1477.	578.
24 0.6	WC	1500.	61.5	2389.	954.	30.0	1205.	487.	42.0	1414.	553.
25 0.6	WC	10000.	70.0	2334.	894.	30.0	409.	192.	30.0	409.	192.
26 0.6	WC	5000.	64.8	2146.	835.	30.0	439.	198.	30.0	439.	198.
27 0.6	WC	1500.	61.5	2026.	789.	30.0	462.	209.	30.0	462.	209.

B-BLUDED DYNASTAT NUN-RIGID

TABLE IV-69
DESIGN VMAX = 70. KNOTS

DESIGN ALTITUDE, H3 = 20000. FT

INC = 250000. L35

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, M3 = 20000. FT																																
MC = 250000. LBS			4			5			6			7			8			9			10			11			12					
LS/MC			H FT.			VMAX KNOTS			BHP			FUEL FLOW LBS/HR			V(MIN BHP) KNOTS			BHP			FUEL FLOW LBS/HR			V(MAX RGE) KNOTS			BHP			FUEL FLOW LBS/HR		
1	1.0	W0	20000.	70.0	2902.	1562.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.	30.0	460.	201.		
2	1.0	W0	10000.	59.5	2428.	965.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.	30.0	546.	228.		
3	1.0	W0	1500.	52.3	2107.	837.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.	30.0	634.	264.		
4	0.6	W0	20000.	70.0	3650.	1965.	43.1	2646.	988.	56.8	3069.	1169.	56.8	3069.	1169.	56.8	3069.	1169.	56.8	3069.	1169.	56.8	3069.	1169.	56.8	3069.	1169.	56.8	3069.	1169.		
5	0.6	W0	10000.	59.5	3068.	1222.	36.7	2270.	864.	50.3	2636.	1022.	50.3	2636.	1022.	50.3	2636.	1022.	50.3	2636.	1022.	50.3	2636.	1022.	50.3	2636.	1022.	50.3	2636.	1022.		
6	0.6	W0	1500.	52.3	2673.	1064.	32.4	2013.	766.	44.5	2341.	908.	44.5	2341.	908.	44.5	2341.	908.	44.5	2341.	908.	44.5	2341.	908.	44.5	2341.	908.	44.5	2341.	908.		
7	0.8	W1	20000.	70.0	2706.	1013.	30.0	823.	338.	38.0	959.	379.	38.0	959.	379.	38.0	959.	379.	38.0	959.	379.	38.0	959.	379.	38.0	959.	379.	38.0	959.	379.		
8	0.8	W1	10000.	59.5	2266.	862.	30.0	788.	320.	32.8	852.	340.	32.8	852.	340.	32.8	852.	340.	32.8	852.	340.	32.8	852.	340.	32.8	852.	340.	32.8	852.	340.		
9	0.8	W1	1500.	52.3	1968.	749.	30.0	800.	325.	30.0	800.	319.	30.0	800.	319.	30.0	800.	319.	30.0	800.	319.	30.0	800.	319.	30.0	800.	319.	30.0	800.	319.		
10	0.8	W2	20000.	70.0	2536.	944.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.		
11	0.8	W2	10000.	59.5	2122.	804.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.		
12	0.8	W2	1500.	52.3	1841.	697.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.		
13	0.6	W3	20000.	70.0	2536.	944.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.	30.0	427.	194.		
14	0.8	W3	10000.	59.5	2122.	804.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.	30.0	502.	220.		
15	0.8	W3	1500.	52.3	1841.	697.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.	30.0	579.	253.		
16	0.6	W0	20000.	70.0	7529.	4053.	67.9	7719.	4765.	91.5	427.	194.	91.5	427.	194.	91.5	427.	194.	91.5	427.	194.	91.5	427.	194.	91.5	427.	194.	91.5	427.	194.		
17	0.6	W0	10000.	59.5	6370.	2544.	57.9	6563.	2656.	78.1	502.	220.	78.1	502.	220.	78.1	502.	220.	78.1	502.	220.	78.1	502.	220.	78.1	502.	220.	78.1	502.	220.		
18	0.6	W0	1500.	52.3	5577.	2227.	51.0	5773.	2336.	68.9	579.	253.	68.9	579.	253.	68.9	579.	253.	68.9	579.	253.	68.9	579.	253.	68.9	579.	253.	68.9	579.	253.		
19	0.6	W1	20000.	70.0	4685.	1758.	55.9	4520.	1701.	75.7	427.	194.	75.7	427.	194.	75.7	427.	194.	75.7	427.	194.	75.7	427.	194.	75.7	427.	194.	75.7	427.	194.		
20	0.6	W1	10000.	59.5	3953.	1530.	47.7	3856.	1502.	64.7	502.	220.	64.7	502.	220.	64.7	502.	220.	64.7	502.	220.	64.7	502.	220.	64.7	502.	220.	64.7	502.	220.		
21	0.6	W1	1500.	52.3	3454.	1337.	42.0	3401.	1325.	57.1	579.	253.	57.1	579.	253.	57.1	579.	253.	57.1	579.	253.	57.1	579.	253.	57.1	579.	253.	57.1	579.	253.		
22	0.6	W2	20000.	70.0	2893.	1090.	40.8	1963.	777.	56.1	2283.	859.	56.1	2283.	859.	56.1	2283.	859.	56.1	2283.	859.	56.1	2283.	859.	56.1	2283.	859.	56.1	2283.	859.		
23	0.6	W2	10000.	59.5	2430.	927.	34.8	1692.	681.	48.1	1972.	764.	48.1	1972.	764.	48.1	1972.	764.	48.1	1972.	764.	48.1	1972.	764.	48.1	1972.	764.	48.1	1972.	764.		
24	0.6	W2	1500.	52.3	2116.	807.	30.7	1507.	606.	42.5	1759.	681.	42.5	1759.	681.	42.5	1759.	681.	42.5	1759.	681.	42.5	1759.	681.	42.5	1759.	681.	42.5	1759.	681.		
25	0.6	W3	20000.	70.0	2154.	824.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.	30.0	441.	211.		
26	0.6	W3	10000.	59.5	1802.	714.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.	30.0	490.	229.		
27	0.6	W3	1500.	52.3	1564.	620.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.	30.0	547.	255.		

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TABLE IV-70
3-LOBED DYNASTAT MCM-RIGID DESIGN VMAX = 70. KNOTS

			RECIPROCATING - COMPOUND ENGINE									
			DESIGN ALTITUDE, H3 = 5000. FT									
			W0 = 625000. LBS									
1	2	3	4	5	6	7	8	9	10	11	12	
LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	500.	70.0	5759.	3806.	30.0	716.	302.	30.0	716.	302.	WF+PL
2	1.0	300.	67.9	5572.	3683.	30.0	744.	314.	30.0	744.	314.	403665.
3	1.0	1500.	66.4	5437.	3594.	30.0	765.	323.	30.0	765.	323.	404921.
4	0.8	500.	70.0	8250.	5453.	47.5	6613.	3882.	64.1	7630.	4935.	376482.
5	0.8	300.	67.9	7991.	5282.	46.1	6418.	3767.	62.3	7406.	4790.	
6	0.8	1500.	66.4	7805.	5159.	45.1	6278.	3685.	60.9	7245.	4685.	
7	0.8	500.	70.0	5146.	2045.	30.0	922.	394.	30.0	922.	394.	
8	0.8	300.	67.9	4979.	1979.	30.0	930.	398.	30.0	930.	398.	
9	0.8	1500.	66.4	4860.	1931.	30.0	938.	401.	30.0	938.	401.	
10	0.8	500.	70.0	5030.	1997.	30.0	650.	288.	30.0	650.	288.	
11	0.8	300.	67.9	4867.	1932.	30.0	675.	298.	30.0	675.	298.	
12	0.8	1500.	66.4	4749.	1886.	30.0	694.	307.	30.0	694.	307.	
13	0.8	500.	70.0	5030.	1997.	30.0	650.	288.	30.0	650.	288.	
14	0.8	300.	67.9	4867.	1932.	30.0	675.	298.	30.0	675.	298.	
15	0.8	1500.	66.4	4749.	1886.	30.0	694.	307.	30.0	694.	307.	
16	0.6	500.	70.0	19831.	13108.	74.9						
17	0.6	300.	67.9	19232.	13108.	72.7						
18	0.6	1500.	66.4	18799.	12426.	71.2						
19	0.6	500.	70.0	10293.	3968.	58.6	9994.	3849.	78.9			
20	0.6	300.	67.9	9976.	3968.	56.9	9697.	3849.	76.6			
21	0.6	1500.	66.4	9748.	3758.	55.7	9482.	3652.	74.9			
22	0.6	500.	70.0	5178.	1997.	36.2	2687.	1039.	49.4	3116.	1239.	
23	0.6	300.	67.9	5013.	1597.	35.2	2612.	1039.	48.0	3030.	1239.	
24	0.6	1500.	66.4	4894.	1887.	34.4	2557.	989.	47.0	2967.	1180.	
25	0.6	500.	70.0	4226.	1616.	30.0	578.	261.	30.0	578.	261.	
26	0.6	300.	67.9	4089.	1616.	30.0	599.	261.	30.0	599.	261.	
27	0.6	1500.	66.4	3990.	1526.	30.0	615.	277.	30.0	615.	277.	

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TABLE IV-71
3-LUBE DYNASTAT MAX-RIGID DESIGN VMAX = 70. KNOTS
RECIPROCATING - COMPOUND ENGINE

WC = 625000. LBS			DESIGN ALTITUDE, H3 = 10000. FT					LS/MO		VOLUME		MF+PL	
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MO		FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	10000.	70.0	5525.	3456.	30.0	695.	306.	30.0	695.	306.	367028.	
2	1.0	5000.	64.8	5077.	3150.	30.0	766.	321.	30.0	766.	321.	308790.	
3	1.0	1500.	61.5	4794.	2974.	30.0	821.	344.	30.0	821.	344.	360604.	
4	0.8	10000.	70.0	8215.	5139.	48.7	6790.	2728.	65.7	7834.	2728.	4641.	
5	0.8	5000.	64.8	7573.	4707.	45.1	6289.	2593.	60.9	7258.	2593.	4395.	
6	0.8	1500.	61.5	7165.	4454.	42.9	5971.	2462.	57.9	6893.	2462.	4174.	
7	0.8	10000.	70.0	4992.	1902.	30.0	1023.	451.	31.8	1078.	451.	472.	
8	0.8	5000.	64.8	4589.	1770.	30.0	1030.	437.	30.0	1030.	437.	472.	
9	0.8	1500.	61.5	4334.	1672.	30.0	1044.	443.	30.0	1044.	443.	443.	
10	0.8	10000.	70.0	4825.	1831.	30.0	632.	291.	30.0	632.	291.	291.	
11	0.8	5000.	64.8	4434.	1708.	30.0	694.	307.	30.0	694.	307.	307.	
12	0.8	1500.	61.5	4187.	1613.	30.0	742.	328.	30.0	742.	328.	328.	
13	0.8	10000.	70.0	4825.	1831.	30.0	632.	291.	30.0	632.	291.	291.	
14	0.8	5000.	64.8	4434.	1708.	30.0	694.	307.	30.0	694.	307.	307.	
15	0.8	1500.	61.5	4187.	1613.	30.0	742.	328.	30.0	742.	328.	328.	
16	0.6	10000.	70.0	20480.	12811.	76.7							
17	0.6	5000.	64.8	18934.	11791.	71.2							
18	0.6	1500.	61.5	17950.	11178.	67.6							
19	0.6	10000.	70.0	10769.	4123.	60.8	10645.	4089.	81.8				
20	0.6	5000.	64.8	9942.	3806.	56.4	9852.	3770.	75.9				
21	0.6	1500.	61.5	9417.	3605.	53.6	9348.	3577.	72.2				
22	0.6	10000.	70.0	5329.	2143.	39.5	3257.	1335.	53.7	3771.	1335.	1486.	
23	0.6	5000.	64.8	4907.	1931.	36.6	3025.	1210.	49.9	3504.	1210.	1358.	
24	0.6	1500.	61.5	4639.	1826.	34.8	2877.	1151.	47.5	3335.	1151.	1292.	
25	0.6	10000.	70.0	4053.	1578.	30.0	563.	261.	30.0	563.	261.	261.	
26	0.6	5000.	64.8	3724.	1423.	30.0	615.	274.	30.0	615.	274.	274.	
27	0.6	1500.	61.5	3517.	1343.	30.0	655.	292.	30.0	655.	292.	292.	

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3-LOBED DYNASTAT NON-RIGID
TABLE IV-72
DESIGN VMAX = 70. KNOTS

3-LOBED DYNASTAT NON-RIGID				DESIGN ALTITUDE, H3 = 20000. FT				RECIPROCATING - COMPOUND ENGINE			
DESIGN VMAX = 70. KNOTS											
W0 = 625000. LBS											
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	20000.	70.0	5064.	2726.	30.0	654.	293.	30.0	654.	293.
2	1.0	10000.	59.5	4236.	1683.	30.0	804.	345.	30.0	804.	345.
3	1.0	1500.	52.3	3676.	1461.	30.0	957.	411.	30.0	957.	411.
4	0.8	20000.	70.0	8200.	4414.	51.2	7181.	2754.	69.1	8285.	4813.
5	0.8	10000.	59.5	6909.	2754.	43.7	6107.	2375.	59.0	7049.	2835.
6	0.8	1500.	52.3	6030.	2404.	38.5	5373.	2090.	52.1	6206.	2496.
7	0.8	20000.	70.0	4725.	1803.	30.0	1316.	574.	37.3	1515.	646.
8	0.8	10000.	59.5	3960.	1566.	30.0	1247.	538.	32.0	1322.	566.
9	0.8	1500.	52.3	3439.	1360.	30.0	1262.	545.	30.0	1262.	540.
10	0.8	20000.	70.0	4420.	1734.	30.0	596.	281.	30.0	596.	281.
11	0.8	10000.	59.5	3696.	1487.	30.0	727.	332.	30.0	727.	332.
12	0.8	1500.	52.3	3209.	1290.	30.0	861.	394.	30.0	861.	394.
13	0.8	20000.	70.0	4420.	1734.	30.0	596.	281.	30.0	596.	281.
14	0.8	10000.	59.5	3696.	1487.	30.0	727.	332.	30.0	727.	332.
15	0.8	1500.	52.3	3209.	1290.	30.0	861.	394.	30.0	861.	394.
16	0.6	20000.	70.0	22024.	11857.	80.7	12203.	4743.	88.6	5497.	2062.
17	0.6	10000.	59.5	18664.	7459.	68.9	10357.	4123.	75.6	4691.	1809.
18	0.6	1500.	52.3	16364.	6540.	60.7	9095.	3621.	66.7	4140.	1596.
19	0.6	20000.	70.0	12065.	4712.	65.9	4757.	1865.	63.4	5497.	2062.
20	0.6	10000.	59.5	10206.	4377.	56.2	4056.	1623.	54.2	4691.	1809.
21	0.6	1500.	52.3	8933.	3569.	49.5	3577.	1431.	47.9	4140.	1596.
22	0.6	20000.	70.0	5969.	2447.	46.9	4757.	1865.	63.4	5497.	2062.
23	0.6	10000.	59.5	5023.	1909.	40.0	4056.	1623.	54.2	4691.	1809.
24	0.6	1500.	52.3	4380.	1664.	35.2	3577.	1431.	47.9	4140.	1596.
25	0.6	20000.	70.0	3724.	1548.	30.0	563.	268.	30.0	563.	268.
26	0.6	10000.	59.5	3116.	1206.	30.0	664.	307.	30.0	664.	307.
27	0.6	1500.	52.3	2704.	1046.	30.0	772.	357.	30.0	772.	357.

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3-LURED DYNASTAT NON-RIGID

TABLE IV-73
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

DESIGN ALTITUDE, H3 = 5000. FT

W0 = 1500000. LBS

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1 1.0	W0	5000.	70.0	9814.	6487.	30.0	1079.	462.	30.0	1079.	462.
2 1.0	W0	3000.	67.9	9496.	6277.	30.0	1127.	483.	30.0	1127.	483.
3 1.0	W0	1500.	66.4	9266.	6125.	30.0	1164.	499.	30.0	1164.	499.
4 C.E	W0	5000.	70.0	18913.	12501.	56.0	17672.	11452.	75.3		
5 C.E	W0	3000.	67.9	18328.	12501.	54.4	17142.	11452.	73.1		
6 0.8	W0	1500.	66.4	17907.	11836.	53.2	16759.	10861.	71.5		
7 0.8	W1	5000.	70.0	8836.	3386.	30.0	1601.	644.	30.3	1615.	648.
8 0.8	W1	3000.	67.9	8550.	3386.	30.0	1605.	644.	30.0	1605.	648.
9 C.E	W1	1500.	66.4	8344.	3197.	30.0	1611.	648.	30.0	1611.	647.
10 C.E	W2	5000.	70.0	8565.	3278.	30.0	967.	418.	30.0	967.	418.
11 C.E	W2	3000.	67.9	8287.	3278.	30.0	1009.	418.	30.0	1009.	418.
12 C.E	W2	1500.	66.4	8087.	3095.	30.0	1041.	450.	30.0	1041.	450.
13 C.E	W3	5000.	70.0	8565.	3278.	30.0	967.	418.	30.0	967.	418.
14 C.E	W3	3000.	67.9	8287.	3278.	30.0	1009.	418.	30.0	1009.	418.
15 0.8	W3	1500.	66.4	8087.	3095.	30.0	1041.	450.	30.0	1041.	450.
16 0.6	W0	5000.	70.0	57331.	37896.	88.4					
17 0.6	W0	3000.	67.9	55612.	37896.	85.8					
18 0.6	W0	1500.	66.4	54372.	35940.	84.0					
19 0.6	W1	5000.	70.0	27279.	10466.	69.7	27478.	10548.	93.5		
20 0.6	W1	3000.	67.9	26451.	10466.	67.6	26650.	10548.	90.8		
21 0.6	W1	1500.	66.4	25853.	9919.	66.2	26053.	10000.	88.9		
22 0.6	W2	5000.	70.0	10735.	4107.	44.4	7759.	3003.	59.8	8949.	3429.
23 0.6	W2	3000.	67.9	10397.	4107.	43.1	7530.	3003.	58.1	8686.	3429.
24 0.6	W2	1500.	66.4	10153.	3885.	42.2	7364.	2850.	56.9	8495.	3256.
25 0.6	W3	5000.	70.0	7188.	2768.	30.0	844.	370.	30.0	844.	370.
26 0.6	W3	3000.	67.9	6955.	2768.	30.0	879.	370.	30.0	879.	370.
27 0.6	W3	1500.	66.4	6787.	2613.	30.0	906.	397.	30.0	906.	397.

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3-LOBED DYNASTAL NON-RIGID

TABLE IV-74
DESIGN VMAX = 70. KNOTS

RECIPROCATING - COMPOUND ENGINE

WC = 150000. LBS DESIGN ALTITUDE, H3 = 10000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	WC	10000.	9422.	5893.	30.0	1044.	466.	30.0	1044.	466.
2	1.0	WC	5000.	8658.	5372.	30.0	1166.	496.	30.0	1166.	496.
3	1.0	WC	1500.	8175.	5372.	30.0	1259.	536.	30.0	1259.	536.
4	1.0	WC	10000.	19115.	11957.	57.4	18158.	10686.	77.1		
5	1.0	WC	5000.	17641.	10974.	53.2	16793.	10134.	71.5		
6	1.0	WC	1500.	16705.	10391.	50.6	15926.	9611.	68.0		
7	1.0	WC	10000.	8631.	3439.	30.0	1892.	737.	33.7	2078.	791.
8	1.0	WC	5000.	7934.	3097.	30.0	1862.	713.	31.4	1940.	744.
9	1.0	WC	1500.	7493.	2925.	30.0	1861.	713.	30.0	1861.	714.
10	1.0	WC	10000.	8221.	3313.	30.0	937.	414.	30.0	937.	414.
11	1.0	WC	5000.	7555.	2894.	30.0	1043.	438.	30.0	1043.	438.
12	1.0	WC	1500.	7133.	2733.	30.0	1124.	472.	30.0	1124.	472.
13	1.0	WC	10000.	8221.	3313.	30.0	937.	414.	30.0	937.	414.
14	1.0	WC	5000.	7555.	2894.	30.0	1043.	438.	30.0	1043.	438.
15	1.0	WC	1500.	7133.	2733.	30.0	1124.	472.	30.0	1124.	472.
16	1.0	WC	10000.	59686.	37335.	90.5					
17	1.0	WC	5000.	55211.	34394.	84.0					
18	1.0	WC	1500.	52364.	32621.	79.8					
19	1.0	WC	10000.	29245.	11417.	72.4					
20	1.0	WC	5000.	27029.	10330.	67.1					
21	1.0	WC	1500.	25619.	9791.	63.8					
22	1.0	WC	10000.	11690.	4725.	48.5	9543.	3874.	65.3	11001.	4320.
23	1.0	WC	5000.	10776.	4121.	45.0	8833.	3381.	60.6	10184.	3912.
24	1.0	WC	1500.	10156.	3899.	42.8	8382.	3208.	57.6	9666.	3713.
25	1.0	WC	10000.	6398.	2677.	30.0	818.	373.	30.0	818.	373.
26	1.0	WC	5000.	6339.	2423.	30.0	907.	395.	30.0	907.	395.
27	1.0	WC	1500.	5786.	2284.	30.0	975.	425.	30.0	975.	425.

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TABLE IV-75
3-LOBE DYNASTAY NON-RIGID DESIGN VMAX = 70. KNOTS
RECIPROCATING - COMPOUND ENGINE

		DESIGN ALTITUDE, H3 = 20000. FT												
WC = 1503000. LBS		1	2	3	4	5	6	7	8	9	10	11	12	
LS/MO				H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1-C	WC	WC	20000.	70.0	8644.	4654.	30.0	975.	444.	30.0	975.	444.	
2	1-C	WC	WC	15000.	55.5	7231.	2873.	30.0	1231.	536.	30.0	1231.	536.	
3	1-C	WC	WC	1500.	52.3	6274.	2493.	30.0	1493.	650.	30.0	1493.	650.	
4	C-8	WC	WC	20000.	70.0	19685.	10597.	60.4	19229.	7632.	81.1	7632.	7632.	
5	C-8	WC	WC	15000.	59.5	16626.	6635.	51.5	16303.	6450.	69.2	6450.	6450.	
6	C-8	WC	WC	1500.	52.3	14539.	5892.	45.4	14301.	5658.	61.0	5658.	5658.	
7	C-8	W1	W1	20000.	70.0	8389.	3301.	30.2	2853.	1065.	41.2	3307.	1377.	
8	0-8	W1	W1	15000.	59.5	7028.	2832.	30.0	2526.	963.	35.3	2838.	1193.	
9	0-8	W1	W1	1500.	52.3	6106.	2460.	30.0	2429.	926.	31.2	2517.	1058.	
10	C-8	W2	W2	20000.	70.0	7541.	3049.	30.0	876.	400.	30.0	876.	400.	
11	0-8	W2	W2	15000.	59.5	6308.	2430.	30.0	1099.	480.	30.0	1099.	480.	
12	C-8	W2	W2	1500.	52.3	5473.	2108.	30.0	1328.	580.	30.0	1328.	580.	
13	C-8	W3	W3	20000.	70.0	7541.	3049.	30.0	876.	400.	30.0	876.	400.	
14	0-8	W3	W3	15000.	59.5	6308.	2430.	30.0	1099.	480.	30.0	1099.	480.	
15	C-8	W3	W3	1500.	52.3	5473.	2108.	30.0	1328.	580.	30.0	1328.	580.	
16	C-6	W0	W0	20000.	70.0	65171.	35085.	95.2						
17	C-6	W0	W0	15000.	59.5	55288.	22107.	81.2						
18	C-6	W0	W0	1500.	52.3	48517.	19400.	71.6						
19	C-6	W1	W1	20000.	70.0	34315.	13545.	78.5						
20	C-6	W1	W1	15000.	59.5	29072.	11529.	67.0						
21	C-6	W1	W1	1500.	52.3	25484.	10106.	59.0						
22	C-6	W2	W2	20000.	70.0	14793.	5684.	57.5	14121.	5531.	77.4	14121.	5531.	
23	C-6	W2	W2	15000.	59.5	12486.	4949.	49.1	11980.	4795.	66.0	11980.	4795.	
24	C-6	W2	W2	1500.	52.3	10912.	4325.	43.3	10516.	4209.	58.2	10516.	4209.	
25	C-6	W3	W3	20000.	70.0	6606.	2634.	30.0	1421.	618.	33.1	1542.	662.	
26	C-6	W3	W3	15000.	59.5	5529.	2253.	30.0	1426.	609.	30.0	1426.	609.	
27	C-6	W3	W3	1500.	52.3	4800.	1956.	30.0	1510.	645.	30.0	1510.	645.	

2-LUBED DYNASTAL NOV-81UD

TABLE IV-76
DESIGN VMAX = 140 KNOTS

WC = 25000. LBS DESIGN ALTITUDE, H3 = 5000. FT

RECIPROCATING - COMPOUND ENGINE

MC = 250000. LBS			DESIGN ALTITUDE, M3 = 5000. FT					LS/MO			VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MC		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	MO	140.0	19640.	12582.	30.0	496.	226.	30.0	496.	226.		
2	1.0	MO	135.9	19205.	12982.	30.0	512.	226.	30.0	512.	226.		
3	1.0	MO	132.5	18986.	12484.	30.0	524.	239.	30.0	524.	239.		
4	0.8	MO	140.0	17576.	11617.	39.9	2448.	951.	54.6	2842.	1152.		
5	0.8	MO	135.9	17188.	11617.	38.8	2380.	951.	53.0	2763.	1152.		
6	0.8	MO	132.5	16903.	11173.	37.9	2331.	905.	51.9	2707.	1097.		
7	0.8	MI	140.0	17433.	11390.	31.0	1293.	533.	43.3	1515.	607.		
8	0.8	MI	135.9	16949.	11390.	30.1	1260.	533.	42.1	1477.	607.		
9	0.8	MI	132.5	16668.	10954.	30.0	1237.	509.	41.2	1449.	581.		
10	0.8	M2	140.0	17206.	11272.	30.0	575.	258.	30.0	575.	258.		
11	0.8	M2	135.9	16825.	11272.	30.0	582.	258.	30.0	582.	258.		
12	0.8	M2	132.5	16546.	10840.	30.0	588.	264.	30.0	588.	264.		
13	0.8	M3	140.0	17185.	11253.	30.0	459.	208.	30.0	459.	208.		
14	0.8	M3	135.9	16805.	11253.	30.0	473.	208.	30.0	473.	208.		
15	0.8	M3	132.5	16526.	10822.	30.0	484.	220.	30.0	484.	220.		
16	0.6	MO	140.0	16372.	10422.	62.9	7116.	2719.	84.8	7862.	3018.		
17	0.6	MO	135.9	16115.	10422.	61.1	6906.	2719.	82.4	7684.	3018.		
18	0.6	MO	132.5	15753.	10413.	59.7	6754.	2581.	80.6	7554.	2900.		
19	0.6	MI	140.0	15508.	10114.	54.5	4791.	1872.	73.7	5476.	2094.		
20	0.6	MI	135.9	15226.	10114.	52.9	4652.	1872.	71.6	5350.	2094.		
21	0.6	MI	132.5	14976.	9730.	51.8	4552.	1778.	70.1	5258.	2011.		
22	0.6	M2	140.0	14984.	9662.	44.6	2821.	1124.	60.8	3247.	1264.		
23	0.6	M2	135.9	14654.	9662.	43.3	2722.	1124.	59.1	3156.	1264.		
24	0.6	M2	132.5	14412.	9294.	42.4	2665.	1070.	57.9	3090.	1203.		
25	0.6	M3	140.0	14622.	9243.	32.2	1223.	502.	45.0	1433.	573.		
26	0.6	M3	135.9	14299.	9243.	31.2	1192.	502.	43.8	1398.	573.		
27	0.6	M3	132.5	14063.	8889.	30.6	1169.	440.	42.9	1372.	548.		

TABLE IV-77
DESIGN VMAX = 14C. KNOTS

3-LCBED DYASTAT Non-RIGID			RECIPROCATING - COMPOUND ENGINE											
W0 = 250000. LBS			DESIGN ALTITUDE, H3 = 10000. FT											
1	2	3	4	5	6	7	8	9	10	11	12			
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WF+PL		
1	1.0	10000.	14C.C	18818.	11771.	30.0	484.	228.	30.0	484.	228.	31811.		
2	1.0	5000.	125.6	17761.	11205.	30.0	525.	238.	30.0	525.	238.	73126.		
3	1.0	1500.	123.C	17064.	10765.	30.0	556.	252.	30.0	556.	252.	93142.		
4	0.8	10000.	14C.C	16871.	10553.	40.9	2510.	954.	55.9	2912.	1225.			
5	0.8	5000.	129.6	15926.	10049.	37.9	2335.	900.	51.9	2711.	1076.			
6	0.8	1500.	123.C	15304.	9656.	36.1	2223.	857.	49.4	2583.	1025.			
7	0.8	10000.	14C.C	16625.	10327.	32.3	1378.	585.	45.0	1611.	666.			
8	0.8	5000.	129.6	15693.	9810.	30.0	1288.	532.	41.8	1509.	607.			
9	0.8	1500.	123.C	15078.	9426.	30.0	1235.	511.	39.8	1443.	581.			
10	0.6	10000.	14C.C	16489.	10138.	30.0	616.	285.	31.4	643.	297.			
11	0.6	5000.	129.6	15564.	9679.	30.0	628.	280.	30.0	628.	280.			
12	0.6	1500.	123.C	14953.	9300.	30.0	641.	286.	30.0	641.	286.			
13	0.6	10000.	14C.C	16459.	10095.	30.0	448.	211.	30.0	448.	211.			
14	0.6	5000.	125.6	15535.	9651.	30.0	484.	219.	30.0	484.	219.			
15	0.6	1500.	123.C	14926.	9272.	30.0	511.	232.	30.0	511.	232.			
16	0.6	10000.	14C.C	15852.	9916.	64.5	7303.	2896.	86.9	8020.	3104.			
17	0.6	5000.	129.6	14976.	9454.	59.8	6764.	2623.	80.7	7564.	2894.			
18	0.6	1500.	123.C	14398.	9089.	56.8	6421.	2490.	76.7	7266.	2780.			
19	0.6	10000.	14C.C	15032.	8821.	56.2	4998.	2024.	76.0	5673.	2230.			
20	0.6	5000.	129.6	14197.	8669.	52.1	4633.	1833.	70.5	5345.	2047.			
21	0.6	1500.	123.C	13646.	8332.	49.5	4402.	1741.	67.0	5087.	1948.			
22	0.6	10000.	14C.C	14428.	8193.	46.5	3008.	1244.	63.4	3485.	1397.			
23	0.6	5000.	129.6	13623.	8080.	43.2	2795.	1127.	58.9	3239.	1269.			
24	0.6	1500.	123.C	13091.	7765.	41.0	2659.	1073.	56.0	3084.	1208.			
25	0.6	10000.	14C.C	14041.	6658.	34.6	1403.	588.	48.1	1641.	667.			
26	0.6	5000.	125.6	13254.	7668.	32.1	1312.	535.	44.7	1536.	608.			
27	0.6	1500.	123.C	12735.	7368.	30.5	1254.	511.	42.6	1469.	582.			

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3-LBLD DYNASTAT NON-RIGID
TABLE IV-78
DESIGN VMAX = 140. KNOTS
RECIPROCATING - COMPOUND ENGINE

W0 = 250000. LBS
DESIGN ALTITUDE, H3 = 20000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL LBS/HR
1 1.0	W0	20000.	140.0	17206.	9263.	30.0	460.	220.	30.0	460.	220.
2 1.0	W0	10000.	118.9	15204.	6189.	30.0	546.	255.	30.0	546.	255.
3 1.0	W0	1500.	104.5	13723.	5586.	30.0	634.	296.	30.0	634.	296.
4 0.8	W0	20000.	140.0	15497.	8343.	43.1	2646.	986.	58.8	3069.	1292.
5 0.8	W0	10000.	118.9	13701.	5576.	36.7	2270.	859.	50.3	2636.	1011.
6 0.8	W0	1500.	104.5	12371.	5037.	32.4	2013.	762.	44.5	2341.	898.
7 0.8	W1	20000.	140.0	15263.	6387.	35.8	1640.	682.	49.4	1913.	768.
8 0.8	W1	10000.	118.9	13491.	5456.	30.5	1419.	595.	42.4	1658.	674.
9 0.8	W1	1500.	104.5	12179.	4926.	30.0	1287.	539.	37.6	1485.	604.
10 0.8	W2	20000.	140.0	15111.	5992.	30.0	839.	384.	38.4	979.	441.
11 0.8	W2	10000.	118.9	13355.	5377.	30.0	800.	361.	33.1	869.	389.
12 0.8	W2	1500.	104.5	12055.	4854.	30.0	809.	365.	30.0	809.	362.
13 0.8	W3	20000.	140.0	15043.	5952.	30.0	452.	216.	30.0	452.	216.
14 0.8	W3	10000.	118.9	13293.	5342.	30.0	520.	242.	30.0	520.	242.
15 0.8	W3	1500.	104.5	11999.	4821.	30.0	593.	276.	30.0	593.	276.
16 0.6	W0	20000.	140.0	14871.	8006.	67.9	7719.	3059.	91.5	8366.	3228.
17 0.6	W0	10000.	118.9	13172.	5368.	57.9	6563.	2551.	78.1	7394.	2903.
18 0.6	W0	1500.	104.5	11913.	4854.	51.0	5773.	2332.	68.9	6664.	2617.
19 0.6	W1	20000.	140.0	14071.	5498.	60.4	5603.	2239.	81.7	6253.	2417.
20 0.6	W1	10000.	118.9	12455.	4952.	51.6	4772.	1941.	69.8	5513.	2168.
21 0.6	W1	1500.	104.5	11257.	4476.	45.4	4204.	1710.	61.6	4860.	1911.
22 0.6	W2	20000.	140.0	13449.	5206.	52.1	3728.	1491.	70.7	4305.	1638.
23 0.6	W2	10000.	118.9	11896.	4676.	44.4	3186.	1295.	60.4	3689.	1449.
24 0.6	W2	1500.	104.5	10746.	4224.	39.1	2815.	1144.	53.4	3263.	1282.
25 0.6	W3	20000.	140.0	13004.	4986.	42.2	2135.	816.	57.8	2481.	925.
26 0.6	W3	10000.	118.9	11498.	4496.	36.0	1837.	723.	49.5	2139.	812.
27 0.6	W3	1500.	104.5	10382.	4060.	31.7	1634.	643.	43.8	1906.	723.

3-LOBBED DYNASTAT NON-RIGID

TABLE IV-79

DESIGN VMAX = 140. KNOTS

WC = 62500. LBS DESIGN ALTITUDE, H3 = 5000. FT

3-LOBBED DYNASTAT NON-RIGID				DESIGN VMAX = 140. KNOTS				RECIPROCATING - COMPOUND ENGINE				
WC = 625000. LBS		DESIGN ALTITUDE, H3 = 5000. FT			LS/WO		VOLUME		WF+PL			
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	WC	140.0	34131.	22561.	30.0	716.	318.	30.0	716.	318.	
2	1.0	WC	135.9	33374.	22561.	30.0	744.	318.	30.0	744.	318.	
3	1.0	WO	132.9	32820.	21694.	30.0	765.	340.	30.0	765.	340.	
4	C.E	WC	140.0	31142.	20585.	47.5	6613.	2544.	64.1	7630.	2915.	
5	C.E	WO	135.9	30456.	20585.	46.1	6418.	2544.	62.3	7406.	2915.	
6	C.E	WO	132.9	29953.	19799.	45.1	6278.	2415.	60.9	7245.	2768.	
7	C.E	W1	140.0	30198.	19707.	34.4	2750.	1092.	46.9	3188.	1268.	
8	C.E	W1	135.9	29530.	19707.	33.4	2672.	1092.	45.5	3099.	1268.	
9	C.E	W1	132.9	29040.	18951.	32.6	2616.	1040.	44.6	3035.	1207.	
10	C.E	W2	140.0	29824.	19397.	30.0	690.	306.	30.0	690.	306.	
11	C.E	W2	135.9	29163.	19397.	30.0	712.	306.	30.0	712.	306.	
12	O.E	W2	132.9	28678.	18651.	30.0	729.	323.	30.0	729.	323.	
13	C.E	W3	140.0	29817.	19391.	30.0	650.	289.	30.0	650.	289.	
14	O.E	W3	135.9	29156.	19391.	30.0	675.	289.	30.0	675.	289.	
15	C.E	W3	132.9	28672.	18646.	30.0	694.	309.	30.0	694.	309.	
16	O.E	WO	140.0	31484.	20811.	74.9	19618.	7797.	100.6	20977.	8376.	
17	O.E	WC	135.9	30804.	20811.	72.7	19152.	7797.	97.7	20513.	8376.	
18	O.E	WO	132.9	30306.	20032.	71.2	18813.	7477.	95.6	20174.	8055.	
19	O.E	W1	140.0	29182.	17851.	62.1	11751.	4491.	83.5	13011.	5014.	
20	C.E	W1	135.9	27567.	17851.	60.3	11401.	4491.	81.1	12712.	5014.	
21	O.E	W1	132.9	27115.	17175.	59.0	11148.	4261.	79.4	12494.	4815.	
22	C.E	W2	140.0	26059.	15713.	46.2	5166.	2026.	62.4	5967.	2282.	
23	O.E	W2	135.9	25485.	15713.	44.8	5015.	2026.	60.6	5793.	2282.	
24	C.E	W2	132.9	25063.	15113.	43.9	4907.	1925.	59.3	5668.	2167.	
25	C.E	W3	140.0	25115.	14679.	30.0	881.	382.	31.2	914.	395.	
26	C.E	W3	135.9	24559.	14679.	30.0	884.	382.	30.4	894.	395.	
27	C.E	W3	132.9	24151.	14116.	30.0	887.	385.	30.0	887.	383.	

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TABLE IV-81
3-LOBED DYNASTAT NON-RIGID DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE											
1	2	3	4	5	6	7	8	9	10	11	12
LS/MO	W	H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL
		FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		LBS/HR
1	1-C	20000.	140.0	30000.	16151.	30.0	654.	307.	30.0	654.	307.
2	1-C	10000.	118.9	26507.	10790.	30.0	804.	366.	30.0	804.	366.
3	1-C	1500.	104.5	23922.	9738.	30.0	957.	436.	30.0	957.	436.
4	C-E	20000.	140.0	27747.	14937.	51.2	7181.	2702.	69.1	8285.	3277.
5	C-E	10000.	118.9	24538.	9992.	43.7	6107.	2378.	59.0	7049.	2843.
6	C-E	1500.	104.5	22162.	9024.	38.5	5373.	2092.	52.1	6206.	2503.
7	C-E	20000.	140.0	26771.	10560.	39.6	3562.	1462.	53.8	4123.	1633.
8	C-E	10000.	118.9	23662.	9483.	33.8	3045.	1265.	46.0	3528.	1423.
9	C-E	1500.	104.5	21361.	8561.	30.0	2692.	1118.	40.7	3121.	1259.
10	C-E	20000.	140.0	26267.	10265.	30.0	1026.	461.	33.2	1118.	496.
11	C-E	10000.	118.9	23210.	9223.	30.0	1037.	457.	30.0	1037.	457.
12	C-E	1500.	104.5	20948.	8325.	30.0	1101.	485.	30.0	1101.	485.
13	C-E	20000.	140.0	26191.	10221.	30.0	596.	281.	30.0	596.	281.
14	C-E	10000.	118.9	23142.	9185.	30.0	727.	331.	30.0	727.	331.
15	C-E	1500.	104.5	20886.	8289.	30.0	861.	393.	30.0	861.	393.
16	C-E	20000.	140.0	29530.	15897.	80.7	20965.	7803.	108.5	22321.	8386.
17	C-E	10000.	118.9	26196.	10682.	68.9	18351.	6982.	92.5	19780.	7561.
18	C-E	1500.	104.5	23720.	9672.	60.7	16096.	6124.	81.6	17910.	6846.
19	C-E	20000.	140.0	26041.	10008.	68.7	13739.	5378.	92.4	14826.	5926.
20	C-E	10000.	118.9	23065.	9034.	58.6	11657.	4664.	78.9	13084.	5281.
21	C-E	1500.	104.5	20859.	8170.	51.7	10233.	4094.	69.5	11795.	4761.
22	C-E	20000.	140.0	23627.	8949.	54.3	7120.	2747.	73.2	8136.	3285.
23	C-E	10000.	118.9	20900.	8089.	46.3	6055.	2401.	62.5	6990.	2862.
24	C-E	1500.	104.5	18980.	7307.	40.8	5328.	2112.	55.2	6153.	2519.
25	C-E	20000.	140.0	22290.	8372.	34.8	2159.	859.	47.8	2509.	945.
26	C-E	10000.	118.9	19700.	7525.	30.0	1858.	751.	40.9	2162.	842.
27	C-E	1500.	104.5	17783.	6793.	30.0	1693.	684.	36.2	1926.	750.

W = 0.25000. LBS DESIGN ALTITUDE, H3 = 20000. FT

*

LS/MO
1.0
0.8
0.6
WF+PL
155804.
18460816.
14768656.
267168.

3-LOBED DYNASTAT NUN-KIGLO
TABLE IV-82
DESIGN VMAX = 140. KNOTS

TABLE IV-82
DESIGN VMAX = 140. KNOTS

WC = 150000. LBS DESIGN ALTITUDE, H3 = 5000. FT

[illegible]

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3-LUBED DYNASTAT NON-RTSD

TABLE IV-83
DESIGN VMAX = 140. KNOTS

RECIPROCATING - COMPOUND ENGINE

W0 = 1500000. LBS		DESIGN ALTITUDE, H3 = 10000. FT		DESIGN VMAX = 140. KNOTS		TABLE IV-83		DESIGN VMAX = 140. KNOTS		RECIPROCATING - COMPOUND ENGINE	
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO	W0	H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL LBS/HR	VMAX RGE) KNOTS	BHP	FUEL LBS/HR
1	1.0	1000.	140.0	55803.	34906.	30.0	1044.	466.	30.0	1044.	466.
2	1.0	5000.	129.6	52663.	33220.	30.0	1166.	495.	30.0	1166.	495.
3	1.0	1500.	123.0	50592.	31914.	30.0	1259.	535.	30.0	1259.	535.
4	0.8	1000.	140.0	53182.	33267.	57.4	18158.	7221.	77.1	20471.	8112.
5	0.8	5000.	129.6	50222.	31693.	53.2	16793.	6424.	71.5	19253.	7435.
6	0.8	1500.	123.0	48268.	30460.	50.6	15926.	6092.	68.0	18344.	7084.
7	0.8	1000.	140.0	49674.	28765.	38.6	6005.	2392.	52.1	6932.	2661.
8	0.8	5000.	129.6	46886.	28355.	35.8	5564.	2168.	48.4	6425.	2459.
9	0.8	1500.	123.0	45047.	27243.	34.0	5283.	2058.	46.0	6102.	2336.
10	0.6	1000.	140.0	48099.	27779.	30.0	937.	420.	30.0	937.	420.
11	0.6	5000.	129.6	45959.	27400.	30.0	1043.	446.	30.0	1043.	446.
12	0.6	1500.	123.0	44152.	26323.	30.0	1124.	481.	30.0	1124.	481.
13	0.6	1000.	140.0	48699.	27779.	30.0	937.	420.	30.0	937.	420.
14	0.6	5000.	129.6	45959.	27400.	30.0	1043.	446.	30.0	1043.	446.
15	0.6	1500.	123.0	44152.	26323.	30.0	1124.	481.	30.0	1124.	481.
16	0.6	1000.	140.0	52593.	39154.	90.5	52097.	20997.	121.4	55062.	24749.
17	0.6	5000.	129.6	59225.	37421.	84.0	49080.	20473.	112.6	52106.	30024.
18	0.6	1500.	123.0	56998.	36013.	79.8	47103.	19649.	107.0	50152.	28898.
19	0.6	1000.	140.0	51926.	20928.	75.9	33067.	12643.	101.9	35314.	13363.
20	0.6	5000.	129.6	49083.	20476.	70.4	31082.	11912.	94.5	33333.	12835.
21	0.6	1500.	123.0	47205.	19692.	66.9	29507.	11309.	89.8	32031.	12334.
22	0.6	1000.	140.0	44828.	17429.	58.1	15848.	6343.	78.1	17813.	7131.
23	0.6	5000.	129.6	42334.	16843.	53.9	14659.	5605.	72.5	16760.	6409.
24	0.6	1500.	123.0	40688.	16188.	51.3	13903.	5316.	68.9	16017.	6125.
25	0.6	1000.	140.0	41296.	15864.	32.6	3215.	1343.	44.4	3723.	1511.
26	0.6	5000.	129.6	38977.	15376.	30.2	2986.	1187.	41.2	3460.	1371.
27	0.6	1500.	123.0	37447.	14724.	30.0	2847.	1132.	39.2	3293.	1305.

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TABLE IV-84
J-3 LUBED DYNASTAT MIN-RIGID DESIGN VMAX = 140 KNOTS

DESIGN ALTITUDE, H3 = 20000, FT										RECIPROCATING - COMPOUND ENGINE			
DESIGN VMAX = 140, KNOTS													
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3-LOBED DYNASTAT "IDEALIZED"										RECIPROCATING - COMPOUND ENGINE									
TABLE IV-85 DESIGN VMAX = 70. KNOTS																			
W0 = 100000. LBS										DESIGN ALTITUDE, H3 = 5000. FT									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LS/WO	LS/WO	H FT.	VMAX KNOTS	BHP	FUEL LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL LBS/HR	V(MAX RGE) KNOTS	3HP	WF+PL	LS/WO	FUEL LBS/HR	V(MAX RGE) KNOTS	3HP	WF+PL	LS/WO	FUEL LBS/HR	V(MAX RGE) KNOTS
1	1.0	5000.	70.0	1585.	1048.	30.0	341.	130.	30.0	341.	36476.	1.0	130.	30.0	341.	36476.	1.0	130.	30.0
2	1.0	3000.	67.9	1534.	1014.	30.0	349.	133.	30.0	349.	39866.	0.8	133.	30.0	349.	39866.	0.8	133.	30.0
3	1.0	1500.	66.4	1497.	989.	30.0	355.	136.	30.0	355.	43099.	0.6	136.	30.0	355.	43099.	0.6	136.	30.0
4	0.8	5000.	70.0	1671.	1105.	35.2	952.	371.	49.9	1123.		0.8	371.	49.9	1123.		0.8	371.	49.9
5	0.8	3000.	67.9	1618.	1069.	34.2	929.	362.	48.6	1097.		0.6	362.	48.6	1097.		0.6	362.	48.6
6	0.8	1500.	66.4	1579.	1044.	33.4	913.	356.	47.6	1078.		0.6	356.	47.6	1078.		0.6	356.	47.6
7	0.8	5000.	70.0	1462.	912.	30.0	488.	192.	38.2	576.		0.8	192.	38.2	576.		0.8	192.	38.2
8	0.8	3000.	67.9	1415.	883.	30.0	485.	191.	37.2	567.		0.6	191.	37.2	567.		0.6	191.	37.2
9	0.8	1500.	66.4	1381.	861.	30.0	484.	190.	36.6	560.		0.6	190.	36.6	560.		0.6	190.	36.6
10	0.8	5000.	70.0	1391.	842.	30.0	324.	127.	30.0	324.		0.8	127.	30.0	324.		0.8	127.	30.0
11	0.8	3000.	67.9	1346.	815.	30.0	331.	129.	30.0	331.		0.6	129.	30.0	331.		0.6	129.	30.0
12	0.8	1500.	66.4	1314.	795.	30.0	336.	131.	30.0	336.		0.6	131.	30.0	336.		0.6	131.	30.0
13	0.8	5000.	70.0	1391.	842.	30.0	324.	127.	30.0	324.		0.8	127.	30.0	324.		0.8	127.	30.0
14	0.8	3000.	67.9	1346.	815.	30.0	331.	129.	30.0	331.		0.6	129.	30.0	331.		0.6	129.	30.0
15	0.8	1500.	66.4	1314.	795.	30.0	336.	131.	30.0	336.		0.6	131.	30.0	336.		0.6	131.	30.0
16	0.6	5000.	70.0	2534.	1675.	55.3	2517.	1659.	75.5			0.6	1659.	75.5			0.6	1659.	75.5
17	0.6	3000.	67.9	2455.	1623.	53.7	2446.	1613.	73.4			0.6	1613.	73.4			0.6	1613.	73.4
18	0.6	1500.	66.4	2399.	1586.	52.5	2396.	1579.	71.8			0.6	1579.	71.8			0.6	1579.	71.8
19	0.6	5000.	70.0	1902.	804.	47.0	1655.	660.	64.9	1929.		0.6	660.	64.9	1929.		0.6	660.	64.9
20	0.6	3000.	67.9	1842.	779.	45.6	1611.	642.	63.1	1879.		0.6	642.	63.1	1879.		0.6	642.	63.1
21	0.6	1500.	66.4	1799.	760.	44.6	1579.	630.	61.8	1842.		0.6	630.	61.8	1842.		0.6	630.	61.8
22	0.6	5000.	70.0	1467.	574.	37.0	936.	370.	52.6	1105.		0.6	370.	52.6	1105.		0.6	370.	52.6
23	0.6	3000.	67.9	1420.	556.	35.9	914.	361.	51.2	1078.		0.6	361.	51.2	1078.		0.6	361.	51.2
24	0.6	1500.	66.4	1386.	543.	35.2	898.	355.	50.1	1061.		0.6	355.	50.1	1061.		0.6	355.	50.1
25	0.6	5000.	70.0	1228.	472.	30.0	421.	170.	38.1	499.		0.6	170.	38.1	499.		0.6	170.	38.1
26	0.6	3000.	67.9	1189.	457.	30.0	420.	170.	37.1	492.		0.6	170.	37.1	492.		0.6	170.	37.1
27	0.6	1500.	66.4	1160.	446.	30.0	420.	169.	36.5	487.		0.6	169.	36.5	487.		0.6	169.	36.5

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TABLE IV-86 3-LOBED DYNASTAT "IDEALIZED" DESIGN VMAX = 70. KNOTS										RECIPROCATING - COMPOUND ENGINE			
W0 = 100000. LBS DESIGN ALTITUDE, H3 = 10000. FT													
1	2	3	4	5	6	7	8	9	10	11	12		
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR		
1	1.0	10000.	70.0	1515.	948.	30.0	335.	134.	30.0	335.	134.		
2	1.0	5000.	64.8	1392.	864.	30.0	355.	136.	30.0	355.	136.		
3	1.0	1500.	61.5	1315.	816.	30.0	370.	141.	30.0	370.	141.		
4	0.8	10000.	70.0	1623.	1015.	36.1	972.	370.	51.1	1146.	445.		
5	0.8	5000.	64.8	1494.	928.	33.5	913.	352.	47.7	1079.	429.		
6	0.8	1500.	61.5	1412.	877.	31.8	876.	338.	45.4	1036.	412.		
7	0.8	10000.	70.0	1406.	576.	30.0	497.	190.	39.3	592.	231.		
8	0.8	5000.	64.8	1293.	550.	30.0	489.	191.	36.8	568.	227.		
9	0.8	1500.	61.5	1221.	519.	30.0	487.	190.	35.2	553.	221.		
10	0.8	10000.	70.0	1329.	532.	30.0	319.	131.	30.0	319.	131.		
11	0.8	5000.	64.8	1222.	499.	30.0	336.	131.	30.0	336.	131.		
12	0.8	1500.	61.5	1154.	472.	30.0	349.	136.	30.0	349.	136.		
13	0.8	10000.	70.0	1329.	532.	30.0	318.	131.	30.0	318.	131.		
14	0.8	5000.	64.8	1222.	499.	30.0	336.	131.	30.0	336.	131.		
15	0.8	1500.	61.5	1154.	472.	30.0	349.	136.	30.0	349.	136.		
16	0.6	10000.	70.0	2551.	1536.	56.7	2578.	1620.	77.5	1997.	787.		
17	0.6	5000.	64.8	2354.	1465.	52.6	2397.	1508.	71.9	1865.	752.		
18	0.6	1500.	61.5	2230.	1387.	50.0	2282.	1436.	68.4	1781.	718.		
19	0.6	10000.	70.0	1900.	743.	48.4	1714.	661.	66.8	1997.	787.		
20	0.6	5000.	64.8	1752.	698.	44.9	1599.	630.	62.1	1865.	752.		
21	0.6	1500.	61.5	1658.	660.	42.7	1526.	601.	59.1	1781.	718.		
22	0.6	10000.	70.0	1446.	547.	38.5	989.	407.	54.6	1165.	463.		
23	0.6	5000.	64.8	1331.	512.	35.8	929.	374.	50.9	1097.	425.		
24	0.6	1500.	61.5	1258.	484.	34.0	891.	358.	48.5	1053.	409.		
25	0.6	10000.	70.0	1188.	470.	30.0	450.	189.	40.1	541.	219.		
26	0.6	5000.	64.8	1093.	423.	30.0	443.	179.	37.6	521.	204.		
27	0.6	1500.	61.5	1032.	400.	30.0	441.	179.	36.0	508.	199.		

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TABLE IV-87												RECIPROCATING - COMPOUND ENGINE				
3-LOBED DYNASTAT			DESIGN VMAX = 70. KNOTS													
IDEALIZED			DESIGN ALTITUDE, H3 = 20000. FT													
WC = 100000. LBS																
1	2	3	4	5	6	7	8	9	10	11	12					
LS/MO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	VOLUME	WF+PL			
												2953731.	26385.			
												2362983.	29611.			
												1772238.	30569.			
1	1.0	20000.	70.0	1379.	742.	30.0	323.	131.	30.0	323.	131.	30.0	323.	131.		
2	1.0	10000.	59.5	1154.	459.	30.0	364.	141.	30.0	364.	141.	30.0	364.	141.		
3	1.0	1500.	52.3	1002.	398.	30.0	406.	157.	30.0	406.	157.	30.0	406.	157.		
4	0.8	20000.	70.0	1536.	827.	38.0	1016.	379.	53.8	1197.	452.	53.8	1197.	452.		
5	0.8	10000.	59.5	1290.	513.	32.4	891.	338.	46.3	1053.	405.	46.3	1053.	405.		
6	0.8	1500.	52.3	1123.	447.	30.0	807.	306.	41.1	955.	367.	41.1	955.	367.		
7	0.8	20000.	70.0	1338.	513.	30.0	612.	257.	44.4	735.	297.	44.4	735.	297.		
8	0.8	10000.	59.5	1122.	435.	30.0	563.	219.	38.5	664.	269.	38.5	664.	269.		
9	0.8	1500.	52.3	975.	378.	30.0	550.	213.	34.4	615.	250.	34.4	615.	250.		
10	0.8	20000.	70.0	1230.	466.	30.0	359.	146.	34.2	402.	159.	34.2	402.	159.		
11	0.8	10000.	59.5	1030.	394.	30.0	381.	150.	30.3	385.	151.	30.3	385.	151.		
12	0.8	1500.	52.3	894.	342.	30.0	409.	161.	30.0	409.	160.	30.0	409.	160.		
13	0.8	20000.	70.0	1208.	457.	30.0	306.	129.	30.0	309.	129.	30.0	309.	129.		
14	0.8	10000.	59.5	1011.	386.	30.0	344.	138.	30.0	344.	138.	30.0	344.	138.		
15	0.8	1500.	52.3	878.	335.	30.0	380.	153.	30.0	380.	153.	30.0	380.	153.		
16	0.6	20000.	70.0	2611.	1405.	59.8	2713.	1677.	81.7			81.7				
17	0.6	10000.	59.5	2205.	880.	51.0	2327.	951.	69.8			69.8				
18	0.6	1500.	52.3	1928.	770.	45.0	2063.	843.	61.7			61.7				
19	0.6	20000.	70.0	2061.	779.	53.6	2036.	769.	73.6			73.6				
20	0.6	10000.	59.5	1738.	664.	45.7	1754.	671.	63.0			63.0				
21	0.6	1500.	52.3	1518.	580.	40.3	1561.	597.	55.8			55.8				
22	0.6	20000.	70.0	1627.	611.	46.6	1432.	559.	64.8	1673.	626.	64.8	1673.	626.		
23	0.6	10000.	59.5	1370.	530.	39.8	1242.	493.	55.5	1456.	555.	55.5	1456.	555.		
24	0.6	1500.	52.3	1194.	462.	35.0	1113.	442.	49.3	1307.	498.	49.3	1307.	498.		
25	0.6	20000.	70.0	1310.	524.	38.5	912.	340.	54.8	1077.	450.	54.8	1077.	450.		
26	0.6	10000.	59.5	1100.	449.	32.8	803.	305.	47.2	952.	370.	47.2	952.	370.		
27	0.6	1500.	52.3	957.	391.	30.0	729.	277.	42.0	867.	337.	42.0	867.	337.		

3-LUBED DYNASTAT			"IDEALIZED"		DESIGN VMAX = 70. KNOTS			TABLE IV-88			RECIPROCATING - COMPOUND ENGINE				
W0 = 250000. LBS			DESIGN ALTITUDE, H3 = 5000. FT												
1	2	3	4	5	6	7	8	9	10	11	12				
LS/W0	H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL	WF+PL				
LS/W0	FT.	KNOTS	LBS/HR	KNOTS	LBS/HR	KNOTS	LBS/HR	KNOTS	BHP	LBS/HR					
1	1.0	W0	5000.	2727.	1802.	30.0	444.	180.	30.0	444.	141264.				
2	1.0	W0	3000.	2839.	1744.	30.0	457.	185.	30.0	457.	143450.				
3	1.0	W0	1500.	2575.	1702.	30.0	467.	189.	30.0	467.	147147.				
4	0.8	W0	5000.	3336.	2205.	42.0	2338.	950.	57.4	2714.					
5	0.8	W0	3000.	3231.	2135.	40.8	2273.	924.	55.8	2647.	1615.				
6	0.8	W0	1500.	3155.	2085.	39.9	2227.	975.	54.6	2586.	1571.				
7	0.8	W1	5000.	2463.	1026.	30.0	590.	235.	33.1	642.	252.				
8	0.8	W1	3000.	2383.	993.	30.0	592.	236.	32.2	631.	247.				
9	0.8	W1	1500.	2326.	969.	30.0	593.	237.	31.6	623.	244.				
10	0.8	W2	5000.	2387.	980.	30.0	413.	175.	30.0	413.	175.				
11	0.8	W2	3000.	2310.	948.	30.0	425.	179.	30.0	425.	179.				
12	0.8	W2	1500.	2254.	925.	30.0	434.	183.	30.0	434.	183.				
13	0.8	W3	5000.	2387.	980.	30.0	413.	175.	30.0	413.	175.				
14	0.8	W3	3000.	2310.	948.	30.0	425.	179.	30.0	425.	179.				
15	0.8	W3	1500.	2254.	925.	30.0	434.	183.	30.0	434.	183.				
16	0.6	W0	5000.	6611.	4370.	66.1	6779.	4515.	89.2						
17	0.6	W0	3000.	6410.	4237.	64.2	6580.	4383.	86.6						
18	0.6	W0	1500.	6265.	4141.	62.8	6436.	4287.	84.8						
19	0.6	W1	5000.	3850.	1510.	52.1	3536.	1365.	70.7						
20	0.6	W1	3000.	3730.	1463.	50.6	3435.	1326.	68.7						
21	0.6	W1	1500.	3644.	1429.	49.5	3362.	1298.	67.3						
22	0.6	W2	5000.	2333.	951.	33.1	1117.	449.	46.6	1312.	511.				
23	0.6	W2	3000.	2259.	921.	32.2	1089.	438.	45.3	1280.	498.				
24	0.6	W2	1500.	2205.	899.	31.5	1069.	430.	44.4	1257.	489.				
25	0.6	W3	5000.	2012.	799.	30.0	380.	172.	30.0	380.	172.				
26	0.6	W3	3000.	1947.	773.	30.0	389.	176.	30.0	389.	176.				
27	0.6	W3	1500.	1900.	754.	30.0	397.	179.	30.0	397.	179.				

3-LOBED DYNASTAT "IDEALIZED"
TABLE IV-89
DESIGN VMAX = 70 KNOTS
RECIPROCATING - COMPOUND ENGINE

TABLE IV-89
DESIGN VMAX = 70. KNOTS

W0 = 250000. LBS		DESIGN ALTITUDE, H3 = 10000. FT					LS/W0		VOLUME		WF+PL
1	2	3	4	5	6	7	8	9	V(MAX KNOTS)	BHP	12 FUEL FLOW LBS/HR
LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR			
1	1-C	10000.	70.0	2612.	1634.	30.0	434.	184.	30.0	434.	184.
2	1-0	5000.	64.8	2401.	1490.	30.0	467.	188.	30.0	467.	188.
3	1-C	1500.	61.5	2267.	1407.	30.0	493.	198.	30.0	493.	198.
4	0-8	10000.	70.0	3285.	2055.	43.0	2396.	934.	58.8	2781.	1129.
5	C-8	5000.	64.8	3026.	1980.	39.9	2230.	887.	54.7	2590.	1083.
6	C-8	1500.	61.5	2861.	1778.	37.9	2124.	845.	52.0	2468.	1032.
7	C-8	10000.	70.0	2380.	927.	30.0	625.	258.	34.9	704.	284.
8	0-8	5000.	64.8	2188.	870.	30.0	623.	248.	32.6	671.	263.
9	0-8	1500.	61.5	2067.	822.	30.0	627.	249.	31.2	650.	255.
10	C-8	10000.	70.0	2285.	886.	30.0	404.	178.	30.0	404.	178.
11	0-8	5000.	64.8	2101.	832.	30.0	434.	183.	30.0	434.	183.
12	C-8	1500.	61.5	1984.	786.	30.0	456.	193.	30.0	456.	193.
13	0-8	10000.	70.0	2285.	886.	30.0	404.	178.	30.0	404.	178.
14	0-8	5000.	64.8	2101.	832.	30.0	434.	183.	30.0	434.	183.
15	C-8	1500.	61.5	1984.	786.	30.0	456.	193.	30.0	456.	193.
16	0-8	10000.	70.0	6767.	4233.	67.8	6957.	4400.	91.4	404.	178.
17	0-6	5000.	64.8	6252.	3892.	62.8	6444.	4095.	84.8	434.	183.
18	C-6	1500.	61.5	5925.	3688.	59.7	6118.	3888.	80.6	456.	193.
19	C-6	10000.	70.0	3931.	1490.	53.9	3718.	1413.	73.1	404.	178.
20	0-6	5000.	64.8	3626.	1397.	50.0	3451.	1325.	67.9	434.	183.
21	C-6	1500.	61.5	3433.	1322.	47.5	3281.	1260.	64.6	456.	193.
22	C-6	10000.	70.0	2324.	900.	35.4	1265.	525.	49.5	1482.	595.
23	0-6	5000.	64.6	2139.	845.	32.9	1184.	478.	46.1	1389.	544.
24	0-6	1500.	61.5	2022.	799.	31.2	1133.	458.	43.9	1330.	520.
25	C-6	10000.	70.0	1925.	728.	30.0	372.	175.	30.0	372.	175.
26	C-6	5000.	64.8	1770.	681.	30.0	397.	180.	30.0	397.	180.
27	C-6	1500.	61.5	1671.	643.	30.0	416.	188.	30.0	416.	188.

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3-LOBED DYNASTAT "IDEALIZED"			DESIGN ALTITUDE, H3 = 20000. FT		RECIPROCATING - COMPOUND ENGINE											
W0 = 250000. LBS			DESIGN ALTITUDE, H3 = 20000. FT		DESIGN VMAX = 70. KNOTS											
1	2	3	4	5	6	7	8	9	10	11	12					
LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	LS/W0	VOLUME	WF+PL		
												1.0	7384329.	117917.		
												0.8	5907461.	123581.		
												0.6	4430595.	125869.		
												*				
1	1.0	20000.	70.0	2387.	1285.	30.0	414.	178.	32.0	414.	178.					
2	1.0	10000.	59.5	1997.	794.	30.0	484.	199.	30.0	484.	199.					
3	1.0	1500.	52.3	1733.	689.	30.0	557.	229.	30.0	557.	229.					
4	0.8	20000.	70.0	3201.	1723.	45.3	2525.	955.	61.9	2930.	1136.					
5	0.8	10000.	59.5	2693.	1073.	38.6	2168.	831.	53.0	2519.	988.					
6	0.8	1500.	52.3	2347.	935.	34.1	1923.	737.	46.9	2238.	878.					
7	0.8	20000.	70.0	2250.	837.	30.0	766.	310.	39.8	903.	348.					
8	0.8	10000.	59.5	1884.	712.	30.0	722.	290.	34.4	806.	315.					
9	0.8	1500.	52.3	1637.	619.	30.0	723.	291.	30.7	739.	289.					
10	0.8	20000.	70.0	2087.	780.	30.0	387.	175.	30.0	387.	175.					
11	0.8	10000.	59.5	1746.	669.	30.0	448.	196.	30.0	448.	196.					
12	0.8	1500.	52.3	1515.	580.	30.0	512.	223.	30.0	512.	223.					
13	0.8	20000.	70.0	2087.	780.	30.0	387.	175.	30.0	387.	175.					
14	0.8	10000.	59.5	1746.	669.	30.0	448.	196.	30.0	448.	196.					
15	0.8	1500.	52.3	1515.	580.	30.0	512.	223.	30.0	512.	223.					
16	0.6	20000.	70.0	7154.	3851.	71.4										
17	0.6	10000.	59.5	6055.	2419.	60.9										
18	0.6	1500.	52.3	5304.	2119.	53.7										
19	0.6	20000.	70.0	4291.	1615.	58.7	4286.	1614.	79.5	2148.	809.					
20	0.6	10000.	59.5	3623.	1416.	50.0	3658.	1426.	67.9	1857.	721.					
21	0.6	1500.	52.3	3168.	1238.	44.1	3229.	1258.	60.0	1659.	644.					
22	0.6	20000.	70.0	2498.	930.	42.6	1845.	732.	58.7	2148.	809.					
23	0.6	10000.	59.5	2100.	794.	36.4	1592.	642.	50.3	1857.	721.					
24	0.6	1500.	52.3	1829.	692.	32.0	1419.	572.	44.6	1659.	644.					
25	0.6	20000.	70.0	1773.	711.	30.0	396.	190.	30.0	396.	190.					
26	0.6	10000.	59.5	1484.	607.	30.0	437.	205.	30.0	437.	205.					
27	0.6	1500.	52.3	1288.	527.	30.0	484.	227.	30.0	484.	227.					

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TABLE IV-91
3-LGBED DYNASTAT "IDEALIZED" DESIGN VMAX = 70. KNOTS
RECIPROCATING - COMPOUND ENGINE

W0 = 625000. LBS DESIGN ALTITUDE, H3 = 5000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	WF+PL FUEL FLOW LBS/HR
1 1.0	W0	5000.	70.0	4734.	3129.	30.0	624.	261.	30.0	624.	437159.
2 1.0	W0	3000.	67.9	4580.	3028.	30.0	647.	271.	30.0	647.	407938.
3 1.0	W0	1500.	66.4	4470.	2955.	30.0	664.	278.	30.0	664.	378996.
4 0.8	W0	5000.	70.0	7357.	4863.	50.0	6295.	3874.	67.5	7265.	4777.
5 0.8	W0	3000.	67.9	7127.	4711.	48.5	6110.	3760.	65.5	7052.	4637.
6 0.8	W0	1500.	66.4	6962.	4602.	47.5	5976.	3678.	64.1	6898.	4536.
7 0.8	W1	5000.	70.0	4246.	1661.	30.0	825.	353.	30.3	833.	356.
8 0.8	W1	3000.	67.9	4108.	1607.	30.0	830.	355.	30.0	830.	354.
9 0.8	W1	1500.	66.4	4009.	1568.	30.0	835.	357.	30.0	835.	357.
10 0.8	W2	5000.	70.0	4136.	1609.	30.0	570.	253.	30.0	570.	253.
11 0.8	W2	3000.	67.9	4002.	1557.	30.0	590.	261.	30.0	590.	261.
12 0.8	W2	1500.	66.4	3906.	1519.	30.0	606.	268.	30.0	606.	268.
13 0.8	W3	5000.	70.0	4136.	1609.	30.0	570.	253.	30.0	570.	253.
14 0.8	W3	3000.	67.9	4002.	1557.	30.0	590.	261.	30.0	590.	261.
15 0.8	W3	1500.	66.4	3906.	1519.	30.0	606.	268.	30.0	606.	268.
16 0.6	W0	5000.	70.0	19083.	12614.	78.8					
17 0.6	W0	3000.	67.9	18508.	12614.	76.5					
18 0.6	W0	1500.	66.4	18093.	11959.	74.8					
19 0.6	W1	5000.	70.0	9496.	3655.	61.5	9455.	3638.	82.8	2893.	1148.
20 0.6	W1	3000.	67.9	9205.	3655.	59.7	9174.	3638.	80.4	2813.	1148.
21 0.6	W1	1500.	66.4	8995.	3462.	58.4	8971.	3452.	78.7	2756.	1094.
22 0.6	W2	5000.	70.0	4392.	1682.	37.7	2493.	962.	51.5	2893.	1148.
23 0.6	W2	3000.	67.9	4252.	1682.	36.6	2424.	962.	50.1	2813.	1148.
24 0.6	W2	1500.	66.4	4151.	1590.	35.8	2374.	915.	49.0	2756.	1094.
25 0.6	W3	5000.	70.0	3478.	1378.	30.0	511.	232.	30.0	511.	232.
26 0.6	W3	3000.	67.9	3365.	1378.	30.0	528.	232.	30.0	528.	232.
27 0.6	W3	1500.	66.4	3284.	1302.	30.0	541.	245.	30.0	541.	245.

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3-LOBED DYNASTAT "IDEALIZED"

TABLE IV-92
DESIGN VMAX = 70. KNOTS

DESIGN ALTITUDE, H3 = 10000. FT

W0 = 625000. LBS

RECIPROCATING - COMPOUND ENGINE

	1	2	3	4	5	6	7	8	9	10	11	12
	LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	10000.	70.0	4561.	2840.	30.0	607.	265.	30.0	607.	265.
2	1.0	W0	5000.	64.8	4173.	2589.	30.0	665.	277.	30.0	665.	277.
3	1.0	W0	1500.	61.5	3940.	2445.	30.0	710.	295.	30.0	710.	295.
4	0.8	W0	10000.	70.0	7357.	4602.	51.2	6462.	2872.	69.1	7458.	4695.
5	0.8	W0	5000.	64.8	6784.	4218.	47.5	5987.	2988.	64.1	6911.	4347.
6	0.8	W0	1500.	61.5	6421.	3992.	45.1	5684.	2837.	61.0	6562.	4128.
7	0.8	W1	10000.	70.0	4125.	1563.	30.0	925.	408.	33.1	1006.	439.
8	0.8	W1	5000.	64.8	3792.	1457.	30.0	924.	392.	30.9	950.	402.
9	0.8	W1	1500.	61.5	3582.	1376.	30.0	931.	396.	30.0	931.	394.
10	0.8	W2	10000.	70.0	3966.	1511.	30.0	555.	256.	30.0	555.	256.
11	0.8	W2	5000.	64.8	3645.	1397.	30.0	606.	268.	30.0	606.	268.
12	0.8	W2	1500.	61.5	3442.	1319.	30.0	645.	286.	30.0	645.	286.
13	0.8	W3	10000.	70.0	3966.	1511.	30.0	555.	256.	30.0	555.	256.
14	0.8	W3	5000.	64.8	3645.	1397.	30.0	606.	268.	30.0	606.	268.
15	0.8	W3	1500.	61.5	3442.	1319.	30.0	645.	286.	30.0	645.	286.
16	0.6	W0	10000.	70.0	19762.	12361.	80.7	10071.	3890.	86.0	3508.	1404.
17	0.6	W0	5000.	64.8	18273.	11381.	74.9	9321.	3565.	79.7	3261.	1275.
18	0.6	W0	1500.	61.5	17326.	10791.	71.1	8844.	3383.	75.8	3104.	1213.
19	0.6	W1	10000.	70.0	9997.	3869.	63.8	10071.	3890.	86.0	3508.	1404.
20	0.6	W1	5000.	64.8	9233.	3530.	59.2	9321.	3565.	79.7	3261.	1275.
21	0.6	W1	1500.	61.5	8747.	3345.	56.3	8844.	3383.	75.8	3104.	1213.
22	0.6	W2	10000.	70.0	4565.	1883.	41.2	3028.	1250.	56.1	3508.	1404.
23	0.6	W2	5000.	64.8	4204.	1619.	38.2	2813.	1133.	52.1	3261.	1275.
24	0.6	W2	1500.	61.5	3975.	1530.	36.3	2677.	1078.	49.5	3104.	1213.
25	0.6	W3	10000.	70.0	3334.	1349.	30.0	498.	233.	30.0	498.	233.
26	0.6	W3	5000.	64.8	3064.	1213.	30.0	541.	243.	30.0	541.	243.
27	0.6	W3	1500.	61.5	2893.	1146.	30.0	574.	258.	30.0	574.	258.

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3-LOBED DYNASTAT "IDEALIZED" TABLE IV-93
DESIGN VMAX = 70. KNOTS
RECIPROCATING - COMPOUND ENGINE

W0 = 625000. LBS DESIGN ALTITUDE, H3 = 20000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	20000.	4159.	2239.	30.0	573.	255.	30.0	573.	255.
2	1.0	W0	10000.	3479.	1383.	30.0	696.	296.	30.0	696.	296.
3	1.0	W0	1500.	3019.	1200.	30.0	822.	350.	30.0	822.	350.
4	0.8	W0	20000.	7411.	3990.	53.9	6833.	2654.	72.7		
5	0.8	W0	10000.	59.5	2492.	46.0	5813.	2278.	62.1		
6	0.8	W0	1500.	5458.	2176.	40.5	5116.	2005.	54.8		
7	0.8	W1	20000.	3928.	1548.	30.0	1217.	529.	39.0	1417.	601.
8	0.8	W1	10000.	3290.	1327.	30.0	1132.	488.	33.5	1239.	527.
9	0.8	W1	1500.	2858.	1153.	30.0	1128.	487.	30.0	1128.	480.
10	0.8	W2	20000.	3632.	1460.	30.0	525.	248.	30.0	525.	248.
11	0.8	W2	10000.	3038.	1247.	30.0	633.	290.	30.0	633.	290.
12	0.8	W2	1500.	2636.	1082.	30.0	743.	341.	30.0	743.	341.
13	0.8	W3	20000.	3632.	1460.	30.0	525.	248.	30.0	525.	248.
14	0.8	W3	10000.	3038.	1247.	30.0	633.	290.	30.0	633.	290.
15	0.8	W3	1500.	2636.	1082.	30.0	743.	341.	30.0	743.	341.
16	0.6	W0	20000.	21363.	11501.	85.0					
17	0.6	W0	10000.	18111.	7240.	72.5					
18	0.6	W0	1500.	15885.	6350.	63.9					
19	0.6	W1	20000.	11349.	4469.	69.2	11547.	4525.	93.1		
20	0.6	W1	10000.	9603.	3863.	59.0	9802.	3925.	79.4		
21	0.6	W1	1500.	8409.	3383.	52.0	8609.	3447.	70.1		
22	0.6	W2	20000.	5247.	1972.	49.0	4443.	1760.	66.3	5135.	1933.
23	0.6	W2	10000.	4418.	1717.	41.8	3790.	1529.	56.7	4385.	1708.
24	0.6	W2	1500.	3854.	1498.	36.8	3344.	1349.	50.1	3872.	1508.
25	0.6	W3	20000.	3057.	1139.	30.0	489.	234.	30.0	489.	234.
26	0.6	W3	10000.	2558.	969.	30.0	575.	268.	30.0	575.	268.
27	0.6	W3	1500.	2220.	841.	30.0	665.	310.	30.0	665.	310.

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3-LUBED DYNASTAT "IDEALIZED" TABLE IV-94
DESIGN VMAX = 70. KNOTS

W0 = 1500000. LBS DESIGN ALTITUDE, H3 = 5000. FT

3-LUBED DYNASTAT "IDEALIZED"				DESIGN VMAX = 70. KNOTS				RECIPROCATING - COMPOUND ENGINE			
W0 = 1500000. LBS				DESIGN ALTITUDE, H3 = 5000. FT				LS/WO			
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	W0	70.0	8058.	5326.	30.0	922.	393.	30.0	922.	393.
2	1.0	W0	67.9	7797.	5154.	30.0	961.	410.	30.0	961.	410.
3	1.0	W0	66.4	7608.	5029.	30.0	991.	423.	30.0	991.	423.
4	0.8	W0	70.0	17382.	11490.	59.0	16800.	10949.	79.2		
5	0.8	W0	67.9	16847.	11490.	57.2	16296.	10949.	76.9		
6	0.8	W0	66.4	16462.	10881.	56.0	15933.	10383.	75.3		
7	0.8	W1	70.0	7291.	2800.	30.0	1430.	578.	31.5	1497.	600.
8	0.8	W1	67.9	7056.	2800.	30.0	1429.	578.	30.7	1460.	600.
9	0.8	W1	66.4	6886.	2644.	30.0	1431.	578.	30.0	1433.	574.
10	0.8	W2	70.0	7034.	2725.	30.0	830.	361.	30.0	830.	361.
11	0.8	W2	67.9	6806.	2725.	30.0	864.	361.	30.0	864.	361.
12	0.8	W2	66.4	6642.	2573.	30.0	891.	387.	30.0	891.	387.
13	0.8	W3	70.0	7034.	2725.	30.0	830.	361.	30.0	830.	361.
14	0.8	W3	67.9	6806.	2725.	30.0	864.	361.	30.0	864.	361.
15	0.8	W3	66.4	6642.	2573.	30.0	891.	387.	30.0	891.	387.
16	0.6	W0	70.0	56049.	37048.	93.0					
17	0.6	W0	67.9	54371.	37048.	90.3					
18	0.6	W0	66.4	53161.	35140.	88.4					
19	0.6	W1	70.0	25883.	9912.	73.2					
20	0.6	W1	67.9	25100.	9912.	71.1					
21	0.6	W1	66.4	24534.	9395.	69.6					
22	0.6	W2	70.0	9358.	3633.	46.4	7239.	2832.	62.6	8351.	3195.
23	0.6	W2	67.9	9064.	3633.	45.0	7026.	2832.	60.8	8105.	3195.
24	0.6	W2	66.4	8852.	3437.	44.1	6872.	2688.	59.5	7928.	3033.
25	0.6	W3	70.0	5905.	2265.	30.0	729.	323.	30.0	729.	323.
26	0.6	W3	67.9	5714.	2265.	30.0	757.	323.	30.0	757.	323.
27	0.6	W3	66.4	5576.	2138.	30.0	780.	345.	30.0	780.	345.

TABLE IV-95
3-LOBED DYNASTAT "IDEALIZED"
DESIGN VMAX = 70. KNOTS

DESIGN ALTITUDE, H3 = 10000. FT

2
/ (MIN 8HP)

MAX RANGE
NOTES

68/51
MOT
TEL
21

4838.
4410.
4164.

397.
421.
453.

37.0
39.0
30.0

97.
21
53.

1037.
10135.
9630.

0025.
00810.
00304.

75.3
71.6

2515.
2375.

664.
660.

32.6
31.1

72.

2312.
2240.

417.

30.0
30.0
30.0

17. 166

2246.

417.

U.S.

17c

10963.

4103.
3704.

3471.
3156.

68.4
63.4

002
030

2295.
2064.

326.
344.
360.

30.0 30.0 30.0

326.
344.
348.

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3-LOBED DYNASTAT "IDEALIZED" TABLE IV-96
DESIGN VMAX = 70. KNOTS
RECIPROCATING - COMPOUND ENGINE

W0 = 150000. LBS DESIGN ALTITUDE, H3 = 20000. FT

1	2	3	4	5	6	7	8	9	10	11	12
LS/W0		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	VMAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1 1.0	W0	20000.	70.0	7094.	3819.	30.0	836.	379.	30.0	836.	379.
2 1.0	W0	10000.	59.5	5934.	2358.	30.0	1046.	453.	30.0	1046.	453.
3 1.0	W0	1500.	52.3	5149.	2046.	30.0	1261.	547.	30.0	1261.	547.
4 C.8	W0	20000.	70.0	18334.	9870.	63.5	18277.	9391.	85.4		
5 0.8	W0	10000.	59.5	15496.	6186.	54.2	15497.	6186.	72.9		
6 C.8	W0	1500.	52.3	13558.	5412.	47.8	13596.	5428.	64.2		
7 C.8	W1	20000.	70.0	7011.	2836.	31.5	2662.	994.	43.1	3087.	1285.
8 0.8	W1	10000.	59.5	5876.	2263.	30.0	2321.	885.	36.9	2652.	1114.
9 0.8	W1	1500.	52.3	5106.	1967.	30.0	2193.	836.	32.6	2354.	989.
10 0.8	W2	20000.	70.0	6190.	2388.	30.0	755.	347.	30.0	755.	347.
11 0.8	W2	10000.	59.5	5178.	2061.	30.0	938.	414.	30.0	938.	414.
12 C.8	W2	1500.	52.3	4493.	1788.	30.0	1126.	497.	30.0	1126.	497.
13 C.8	W3	20000.	70.0	6190.	2388.	30.0	755.	347.	30.0	755.	347.
14 0.8	W3	10000.	59.5	5178.	2061.	30.0	938.	414.	30.0	938.	414.
15 0.8	W3	1500.	52.3	4493.	1788.	30.0	1126.	497.	30.0	1126.	497.
16 C.6	W0	20000.	70.0	64039.	34475.	100.2					
17 0.6	W0	10000.	59.5	54341.	21731.	85.5					
18 0.6	W0	1500.	52.3	47596.	19073.	75.4					
19 0.6	W1	20000.	70.0	33043.	13114.	82.5					
20 C.6	W1	10000.	59.5	28006.	11159.	70.4					
21 C.6	W1	1500.	52.3	24558.	9785.	62.0					
22 C.6	W2	20000.	70.0	13508.	5330.	60.3	13248.	5255.	81.1		
23 0.6	W2	10000.	59.5	11409.	4599.	51.4	11241.	4547.	69.2		
24 C.6	W2	1500.	52.3	9976.	4022.	45.3	9869.	3992.	61.0		
25 0.6	W3	20000.	70.0	5433.	2035.	30.0	1225.	543.	33.7	1346.	589.
26 C.6	W3	10000.	59.5	4548.	1753.	30.0	1223.	532.	30.0	1223.	532.
27 C.6	W3	1500.	52.3	3949.	1522.	30.0	1288.	561.	30.0	1288.	561.

RECIPROCATING - COMPOUND ENGINE

TABLE IV-97
DESIGN VMAX = 140. KNOTS

3-LUBED DYNASTY "IDEALIZED"

WC = 25000. LBS DESIGN ALTITUDE, H3 = 5000. FT

WC = 25000G. LBS		DESIGN ALTITUDE, H3 = 5000. FT							VOLUME			WF+PL
1	2	3	4	5	6	7	8	9	10	11	12	
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	
1	1.0	WO	140.0	16190.	10701.	30.0	444.	201.	30.0	444.	201.	4568873.
2	1.0	WO	135.9	15831.	10701.	30.0	457.	201.	30.0	457.	201.	84492.
3	1.0	WO	132.9	15569.	10291.	30.0	467.	212.	30.0	467.	212.	3655097.
4	C.8	WO	140.0	14568.	9629.	42.0	2338.	898.	57.4	2714.	1055.	2741323.
5	C.8	WO	135.9	14247.	9629.	40.8	2273.	898.	55.8	2640.	1055.	
6	0.8	WO	132.9	14012.	9262.	39.9	2227.	855.	54.6	2586.	1005.	
7	0.8	W1	140.0	14308.	9386.	31.6	1149.	488.	44.3	1349.	560.	
8	0.8	W1	135.9	13992.	9386.	30.6	1120.	488.	43.1	1316.	560.	
9	0.8	W1	132.9	13760.	9027.	30.0	1099.	467.	42.2	1292.	537.	
10	0.8	W2	140.0	14187.	9274.	30.0	466.	213.	30.0	466.	213.	
11	0.8	W2	135.9	13873.	9274.	30.0	475.	213.	30.0	475.	213.	
12	0.8	W2	132.9	13643.	8919.	30.0	482.	220.	30.0	482.	220.	
13	C.8	W3	140.0	14177.	9266.	30.0	413.	189.	30.0	413.	189.	
14	0.8	W3	135.9	13864.	9266.	30.0	425.	189.	30.0	425.	189.	
15	C.8	W3	132.9	13634.	8911.	30.0	434.	199.	30.0	434.	199.	
16	0.6	WO	140.0	13852.	9156.	66.1	6779.	2606.	89.2	7407.	2856.	
17	0.6	WO	135.9	13551.	9156.	64.2	6580.	2606.	86.6	7235.	2856.	
18	0.6	WO	132.9	13331.	8812.	62.8	6436.	2474.	84.8	7114.	2746.	
19	0.6	W1	140.0	13003.	8432.	56.6	4434.	1702.	76.7	5025.	1994.	
20	C.6	W1	135.9	12719.	8432.	55.0	4305.	1702.	74.5	4911.	1994.	
21	0.6	W1	132.9	12510.	8112.	53.8	4212.	1617.	72.9	4828.	1915.	
22	0.6	W2	140.0	12405.	7860.	45.4	2453.	947.	62.0	2847.	1131.	
23	0.6	W2	135.9	12132.	7860.	44.1	2385.	947.	60.3	2768.	1131.	
24	0.6	W2	132.9	11932.	7561.	43.1	2336.	901.	59.0	2711.	1077.	
25	0.6	W3	140.0	12057.	7499.	30.6	935.	404.	43.6	1103.	468.	
26	0.6	W3	135.9	11791.	7499.	30.0	912.	404.	42.4	1078.	468.	
27	0.6	W3	132.9	11596.	7212.	30.0	897.	388.	41.5	1059.	449.	

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3-LOBED DYNASTAT "IDEALIZED"										RECIPROCATING - COMPOUND ENGINE				
TABLE IV-98										DESIGN VMAX = 140. KNOTS				
WG = 250000. LBS										DESIGN ALTITUDE, H3 = 10000. FT				
1	2	3	4	5	6	7	8	9	10	11	12			
LS/WO	H	FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WF+PL	VOLUME	
1 1.0	W0	10000.	140.0	15503.	9697.	30.0	434.	204.	30.0	434.	204.	43084.	5330437.	
2 1.0	W0	5000.	129.6	14633.	9231.	30.0	467.	211.	30.0	467.	211.	80633.	4264348.	
3 1.0	W0	1500.	123.0	14059.	8869.	30.0	493.	223.	30.0	493.	223.	99582.	3198261.	
4 0.8	W0	10000.	140.0	13981.	8745.	43.0	2396.	923.	58.8	2781.	1058.			
5 0.8	W0	5000.	129.6	13190.	8328.	39.9	2230.	853.	54.7	2590.	999.			
6 0.8	W0	1500.	123.0	12684.	8003.	37.9	2124.	813.	52.0	2468.	952.			
7 0.8	W1	10000.	140.0	13716.	8475.	32.9	1223.	536.	46.1	1434.	615.			
8 0.8	W1	5000.	129.6	12948.	8072.	30.5	1145.	488.	42.9	1345.	561.			
9 0.8	W1	1500.	123.0	12441.	7756.	30.0	1097.	467.	40.8	1288.	537.			
10 0.8	W2	10000.	140.0	13585.	8288.	30.0	492.	232.	30.0	492.	232.			
11 0.8	W2	5000.	129.6	12823.	7946.	30.0	509.	231.	30.0	509.	231.			
12 0.8	W2	1500.	123.0	12321.	7635.	30.0	524.	238.	30.0	524.	238.			
13 0.8	W3	10000.	140.0	13570.	8266.	30.0	464.	192.	30.0	404.	192.			
14 0.8	W3	5000.	129.6	12808.	7931.	30.0	434.	199.	30.0	434.	199.			
15 0.8	W3	1500.	123.0	12306.	7621.	30.0	456.	209.	30.0	456.	209.			
16 0.6	W0	10000.	140.0	13431.	8401.	67.8	6957.	2675.	91.4	7545.	2857.			
17 0.6	W0	5000.	129.6	12692.	8013.	62.8	6444.	2466.	84.8	7122.	2742.			
18 0.6	W0	1500.	123.0	12204.	7704.	59.7	6118.	2341.	80.6	6845.	2635.			
19 0.6	W1	10000.	140.0	12562.	7282.	58.4	4622.	1779.	79.1	5203.	2143.			
20 0.6	W1	5000.	129.6	11866.	7185.	54.2	4286.	1640.	73.4	4906.	1891.			
21 0.6	W1	1500.	123.0	11406.	6907.	51.5	4073.	1559.	69.8	4709.	1815.			
22 0.6	W2	10000.	140.0	11941.	5825.	47.4	2636.	1001.	64.7	3057.	1183.			
23 0.6	W2	5000.	129.6	11275.	6547.	43.9	2451.	945.	60.1	2844.	1125.			
24 0.6	W2	1500.	123.0	10836.	6291.	41.8	2334.	899.	57.1	2709.	1071.			
25 0.6	W3	10000.	140.0	11566.	4732.	33.2	1084.	479.	46.8	1274.	552.			
26 0.6	W3	5000.	129.6	10919.	5410.	30.8	1017.	437.	43.6	1197.	504.			
27 0.6	W3	1500.	123.0	10492.	5198.	30.0	975.	419.	41.5	1148.	484.			

END

END

7592.

1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1-C	20000.	140-C	14160.	7623.	30.0	414.	197.	30.0	414.	197.
2	1-C	10000.	118.9	12513.	5094.	30.0	484.	225.	30.0	484.	225.
3	1-C	1500.	104.5	11295.	4598.	30.0	557.	259.	30.0	557.	259.
4	0.8	20000.	140-C	12842.	6913.	45.3	2525.	952.	61.9	2930.	1092.
5	0.8	10000.	118.9	11355.	4624.	38.6	2168.	847.	53.0	2519.	952.
6	0.8	1500.	104.5	10255.	4176.	34.1	1923.	752.	46.9	2238.	846.
7	0.8	20000.	140-C	12584.	5002.	36.6	1463.	632.	50.8	1709.	719.
8	0.8	10000.	118.9	11124.	4489.	31.2	1269.	550.	43.6	1486.	629.
9	0.8	1500.	104.5	10043.	4053.	30.0	1147.	497.	38.6	1334.	564.
10	0.8	20000.	140-C	12431.	4912.	30.0	660.	310.	37.3	766.	356.
11	0.8	10000.	118.9	10987.	4410.	30.0	646.	299.	32.3	689.	317.
12	0.8	1500.	104.5	9918.	3981.	30.0	664.	307.	30.0	664.	306.
13	0.8	20000.	140-C	12383.	4883.	30.0	387.	187.	30.0	387.	187.
14	0.8	10000.	118.9	10944.	4385.	30.0	448.	212.	39.0	448.	212.
15	0.8	1500.	104.5	9879.	3958.	30.0	512.	242.	30.0	512.	242.
16	0.6	20000.	140-C	12646.	6808.	71.4	7319.	2785.	96.3	7863.	2951.
17	0.6	10000.	118.9	11207.	4568.	60.9	6250.	2458.	82.2	6962.	2659.
18	0.6	1500.	104.5	10139.	4133.	53.7	5499.	2163.	72.5	6302.	2407.
19	0.6	20000.	140-C	11790.	4589.	62.9	5186.	1948.	85.1	5736.	2349.
20	0.6	10000.	118.9	10439.	4124.	53.7	4420.	1711.	72.7	5068.	2089.
21	0.6	1500.	104.5	9437.	3729.	47.3	3896.	1508.	64.1	4505.	1857.
22	0.6	20000.	140-C	11141.	4281.	53.2	3294.	1244.	72.3	3788.	1554.
23	0.6	10000.	118.9	9857.	3859.	45.4	2818.	1077.	61.9	3266.	1355.
24	0.6	1500.	104.5	8905.	3487.	40.0	2493.	953.	54.7	2893.	1200.
25	0.6	20000.	140-C	10700.	4078.	41.5	1723.	721.	57.3	2008.	813.
26	0.6	10000.	118.9	9461.	3681.	35.4	1489.	628.	49.1	1739.	713.
27	0.6	1500.	104.5	8543.	3324.	31.2	1329.	560.	43.5	1555.	637.

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3-LOBED DYNASTAT "IDEALIZED" TABLE IV-100
DESIGN VMAX = 140. KNOTS
RECIPROCATING - COMPOUND ENGINE

WC = 625000. LBS		DESIGN ALTITUDE, H3 = 5000. FT											
1	2	3	4	5	6	7	8	9	10	11	12		
LS/MO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V (MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V (MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR	WE+PL	
1 1.0	W0	5000.	140.0	28068.	18593.	30.0	624.	279.	30.0	624.	279.	219197.	
2 1.0	W0	3000.	135.9	27445.	18553.	30.0	647.	279.	30.0	647.	279.	250137.	
3 1.0	W0	1500.	132.9	26990.	17840.	30.0	664.	297.	30.0	664.	297.	313379.	
4 0.8	W0	5000.	140.0	25857.	17091.	50.0	6295.	2419.	67.5	7265.	2786.		
5 0.8	W0	3000.	135.9	25288.	17091.	48.5	6110.	2419.	65.5	7052.	2786.		
6 0.8	W0	1500.	132.9	24870.	16439.	47.5	5976.	2297.	64.1	6898.	2645.		
7 0.8	W1	5000.	140.0	24863.	16179.	34.8	2383.	924.	47.7	2766.	1101.		
8 0.8	W1	3000.	135.9	24313.	16179.	33.8	2316.	924.	46.3	2690.	1101.		
9 0.8	W1	1500.	132.9	23909.	15559.	33.1	2269.	880.	45.4	2635.	1049.		
10 0.8	W2	5000.	140.0	24532.	15933.	30.0	570.	255.	30.0	570.	255.		
11 0.8	W2	3000.	135.9	23988.	15933.	30.0	590.	255.	30.0	590.	255.		
12 0.8	W2	1500.	132.9	23590.	15321.	30.0	606.	271.	30.0	606.	271.		
13 0.6	W3	5000.	140.0	24532.	15933.	30.0	570.	255.	30.0	570.	255.		
14 0.6	W3	3000.	135.9	23988.	15933.	30.0	590.	255.	30.0	590.	255.		
15 0.6	W3	1500.	132.9	23590.	15321.	30.0	606.	271.	30.0	606.	271.		
16 0.6	W0	5000.	140.0	27056.	17884.	78.8	18445.	7393.	105.8	19668.	8135.		
17 0.6	W0	3000.	135.9	26475.	17884.	76.5	18013.	7393.	102.7	19239.	8135.		
18 0.6	W0	1500.	132.9	26049.	17218.	74.8	17697.	7093.	100.5	18926.	7828.		
19 0.6	W1	5000.	140.0	23662.	14760.	64.8	10939.	4238.	87.2	11986.	4584.		
20 0.6	W1	3000.	135.9	23146.	14760.	62.9	10613.	4238.	84.7	11714.	4584.		
21 0.6	W1	1500.	132.9	22768.	14203.	61.6	10378.	4020.	82.9	11515.	4404.		
22 0.6	W2	5000.	140.0	21528.	12554.	47.2	4556.	1755.	63.9	5264.	2058.		
23 0.6	W2	3000.	135.9	21054.	12554.	45.8	4423.	1755.	62.1	5112.	2058.		
24 0.6	W2	1500.	132.9	20707.	12075.	44.8	4328.	1667.	60.8	5002.	1955.		
25 0.6	W3	5000.	140.0	20657.	9917.	30.0	642.	286.	30.0	642.	286.		
26 0.6	W3	3000.	135.9	20199.	9917.	30.0	651.	286.	30.0	651.	286.		
27 0.6	W3	1500.	132.9	19864.	9536.	30.0	659.	294.	30.0	659.	294.		

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3-LOBED DYNASTAT "IDEALIZED" TABLE IV-101
DESIGN VMAX = 140. KNOTS

DESIGN ALTITUDE, H3 = 10000. FT		RECIPROCATING - COMPOUND ENGINE											
LS/WO	H FT.	4 VMAX KNOTS	5 BHP	6 FUEL FLOW LBS/HR	7 V(MIN BHP) KNOTS	8 BHP	9 FUEL FLOW LBS/HR	10 V(MAX RGE) KNOTS	11 BHP	12 FUEL FLOW LBS/HR			
1 1.0	1000.	140.0	26916.	16836.	30.0	607.	282.	30.0	607.	282.	LS/WO	VOLUME	WF+PL
2 1.0	500.	129.6	25403.	16025.	30.0	665.	297.	30.0	665.	297.	1.0	13326094.	207679.
3 1.0	1500.	123.0	24405.	15396.	30.0	710.	317.	30.0	710.	317.	0.8	10660874.	241294.
											* 0.6	7995655.	305361.
4 0.8	1000.	140.0	24914.	15584.	51.2	6462.	2484.	69.1	7458.	2975.			
5 0.8	500.	129.6	23523.	14643.	47.5	5987.	2291.	64.1	6911.	2696.			
6 0.8	1500.	123.0	22606.	14264.	45.1	5684.	2175.	61.0	6562.	2560.			
7 0.8	1000.	140.0	23892.	14287.	36.4	2561.	977.	49.7	2972.	1242.			
8 0.8	500.	129.6	22552.	13862.	33.7	2382.	921.	46.1	2765.	1099.			
9 0.8	1500.	123.0	21668.	13318.	32.0	2268.	877.	43.9	2634.	1047.			
10 0.8	1000.	140.0	23520.	13731.	30.0	565.	262.	30.0	565.	262.			
11 0.8	500.	129.6	22198.	13512.	30.0	615.	274.	30.0	615.	274.			
12 0.8	1500.	123.0	21327.	12982.	30.0	653.	291.	30.0	653.	291.			
13 0.8	1000.	140.0	23518.	13730.	30.0	555.	258.	30.0	555.	258.			
14 0.8	500.	129.6	22197.	13511.	30.0	606.	271.	30.0	606.	271.			
15 0.8	1500.	123.0	21325.	12980.	30.0	645.	288.	30.0	645.	288.			
16 0.6	1000.	140.0	26534.	16598.	80.7	18837.	7318.	108.4	20058.	7861.			
17 0.6	500.	129.6	25091.	15847.	74.9	17726.	7049.	100.6	18956.	7577.			
18 0.6	1500.	123.0	24137.	15245.	71.1	16999.	6760.	95.6	18231.	7287.			
19 0.6	1000.	140.0	23035.	9457.	66.8	11424.	4602.	89.9	12422.	4906.			
20 0.6	500.	129.6	21764.	11451.	61.9	10572.	4045.	83.4	11713.	4505.			
21 0.6	1500.	123.0	20925.	11099.	58.9	10030.	3838.	79.2	11248.	4326.			
22 0.6	1000.	140.0	20798.	8197.	49.4	4963.	1880.	66.9	5733.	2307.			
23 0.6	500.	129.6	19637.	7962.	45.9	4601.	1769.	62.1	5316.	2091.			
24 0.6	1500.	123.0	18871.	7652.	43.6	4371.	1681.	59.0	5052.	1987.			
25 0.6	1000.	140.0	19821.	7754.	30.0	768.	351.	32.6	826.	375.			
26 0.6	500.	129.6	18708.	7469.	30.0	773.	341.	30.4	783.	345.			
27 0.6	1500.	123.0	17974.	7176.	30.0	783.	345.	30.0	783.	345.			

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3-LOBED DYNASTAT "IDEALIZED"										DESIGN VMAX = 140. KNOTS				TABLE IV-102				RECIPROCATING - COMPOUND ENGINE				
W0 = 625000. LBS										DESIGN ALTITUDE, H3 = 20000. FT												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
LS/WO	W0	H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL	LS/WO	W0	H	VMAX	BHP	FUEL	V(MAX RGE)	BHP	FUEL	LS/WO	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1	1.0	20000.	140.0	24647.	13269.	30.0	573.	271.	30.0	573.	271.	1.0	18460816.	175798.	1.0	18460816.	175798.	1.0	18460816.	175798.	1.0	18460816.
2	1.0	10000.	118.9	21777.	8865.	30.0	696.	319.	30.0	696.	319.	0.8	14768656.	212348.	0.8	14768656.	212348.	0.8	14768656.	212348.	0.8	14768656.
3	1.0	1500.	104.5	19655.	8001.	30.0	822.	377.	30.0	822.	377.	* 0.6	11076491.	277602.	* 0.6	11076491.	277602.	* 0.6	11076491.	277602.	* 0.6	11076491.
4	0.8	20000.	140.0	23080.	12425.	53.9	6833.	2575.	72.7	7822.	3116.	0.8	14768656.	212348.	0.8	14768656.	212348.	0.8	14768656.	212348.	0.8	14768656.
5	0.8	10000.	118.9	20415.	8314.	46.0	5813.	2275.	62.1	6711.	2718.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
6	0.8	1500.	104.5	18442.	7510.	40.5	5116.	2002.	54.8	5909.	2393.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
7	0.8	20000.	140.0	22040.	8650.	40.4	3126.	1310.	55.0	3621.	1470.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
8	0.8	10000.	118.9	19481.	7772.	34.5	2676.	1032.	47.1	3104.	1278.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
9	0.8	1500.	104.5	17588.	7017.	30.4	2369.	913.	41.6	2750.	1132.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
10	0.8	20000.	140.0	21560.	8394.	30.0	725.	336.	30.0	725.	336.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
11	0.8	10000.	118.9	19051.	7527.	30.0	777.	351.	30.0	777.	351.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
12	0.8	1500.	104.5	17195.	6794.	30.0	854.	386.	30.0	854.	386.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
13	0.6	20000.	140.0	21525.	8378.	30.0	525.	249.	30.0	525.	249.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
14	0.6	10000.	118.9	19020.	7511.	30.0	633.	291.	30.0	633.	291.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
15	0.6	1500.	104.5	17166.	6779.	30.0	743.	342.	30.0	743.	342.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
16	0.6	20000.	140.0	25620.	13793.	85.0	19689.	7416.	114.1	20903.	7934.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
17	0.6	10000.	118.9	22743.	9276.	72.5	17320.	6634.	97.4	18556.	7197.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
18	0.6	1500.	104.5	20603.	8404.	63.9	15307.	5863.	85.9	16823.	6525.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
19	0.6	20000.	140.0	22017.	8406.	71.8	12729.	5101.	96.5	13652.	5371.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
20	0.6	10000.	118.9	19509.	7611.	61.2	10859.	4239.	82.4	12066.	4802.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
21	0.6	1500.	104.5	17648.	6885.	54.0	9535.	3722.	72.6	10905.	4340.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
22	0.6	20000.	140.0	19575.	7367.	55.8	6344.	2544.	75.3	7209.	2781.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
23	0.6	10000.	118.9	17318.	6633.	47.6	5399.	2203.	64.3	6235.	2461.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
24	0.6	1500.	104.5	15646.	5993.	41.9	4753.	1939.	56.8	5492.	2168.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
25	0.6	20000.	140.0	18294.	6815.	33.5	1644.	696.	46.4	1917.	787.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
26	0.6	10000.	118.9	16169.	6161.	30.0	1426.	607.	39.8	1662.	689.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.
27	0.6	1500.	104.5	14596.	5562.	30.0	1321.	562.	35.2	1488.	617.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.	277602.	0.6	11076491.

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TABLE IV-103
3-LOBED DYNASTAT "IDEALIZED" DESIGN VMAX = 140. KNOTS

W0 = 1500000. LBS DESIGN ALTITUDE, H3 = 5000. FT

		RECIPROCATING - COMPOUND ENGINE									
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO		H FT.	VMAX KNOTS	BHP	FUEL FLOW LBS/HR	V(MIN BHP) KNOTS	BHP	FUEL FLOW LBS/HR	V(MAX RGE) KNOTS	BHP	FUEL FLOW LBS/HR
1	1.0	5000.	140.0	47741.	31557.	30.0	922.	400.	30.0	922.	400.
2	1.0	3000.	135.9	46681.	31557.	30.0	961.	400.	30.0	961.	400.
3	1.0	1500.	132.9	45905.	30343.	30.0	991.	431.	30.0	991.	431.
4	0.8	5000.	140.0	45935.	30366.	59.0	16800.	6501.	79.2	18823.	7269.
5	0.8	3000.	135.9	44932.	30366.	57.2	16296.	6501.	76.9	18383.	7269.
6	0.8	1500.	132.9	44194.	29212.	56.0	15933.	6165.	75.3	18062.	6975.
7	0.8	5000.	140.0	42432.	27430.	37.6	4796.	1849.	50.8	5541.	2150.
8	0.8	3000.	135.9	41492.	27430.	36.5	4656.	1849.	49.4	5381.	2150.
9	0.8	1500.	132.9	40804.	26378.	35.7	4556.	1757.	48.3	5265.	2042.
10	0.8	5000.	140.0	41680.	26739.	30.0	830.	363.	30.0	830.	363.
11	0.8	3000.	135.9	40756.	26739.	30.0	864.	363.	30.0	864.	363.
12	0.8	1500.	132.9	40078.	25711.	30.0	891.	389.	30.0	891.	389.
13	0.6	5000.	140.0	41680.	26739.	30.0	830.	363.	30.0	830.	363.
14	0.6	3000.	135.9	40756.	26739.	30.0	864.	363.	30.0	864.	363.
15	0.6	1500.	132.9	40078.	25711.	30.0	891.	389.	30.0	891.	389.
16	0.6	5000.	140.0	55637.	36776.	93.0	47845.	29535.	124.7	50486.	32393.
17	0.6	3000.	135.9	54462.	36776.	90.3	46757.	29535.	121.1	49427.	32393.
18	0.6	1500.	132.9	53599.	35629.	88.4	45962.	28373.	118.5	48650.	31215.
19	0.6	5000.	140.0	44931.	26557.	76.9	29269.	11290.	103.2	31239.	12149.
20	0.6	3000.	135.9	43963.	26557.	74.7	28576.	11290.	100.2	30550.	12149.
21	0.6	1500.	132.9	43253.	25565.	73.1	28071.	10827.	98.1	30046.	11685.
22	0.6	5000.	140.0	38098.	15302.	56.8	12731.	4874.	76.4	14391.	5503.
23	0.6	3000.	135.9	37261.	15302.	55.2	12351.	4874.	74.2	14053.	5503.
24	0.6	1500.	132.9	36649.	14720.	54.0	12076.	4623.	72.6	13807.	5280.
25	0.6	5000.	140.0	35136.	13973.	30.0	1498.	608.	35.0	1681.	667.
26	0.6	3000.	135.9	34357.	13973.	30.0	1482.	608.	34.0	1638.	667.
27	0.6	1500.	132.9	33787.	13436.	30.0	1473.	597.	33.3	1607.	637.

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3-LOBED DYNASTAT "IDEALIZED"

TABLE IV-104

DESIGN VMAX = 140. KNOTS

DESIGN ALTITUDE, H3 = 10000. FT

W0 = 1500000. LBS

1	2	3	4	5	6	7	8	9	10	11	12
LS/W0	H	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	VOLUME	LS/W0	BHP	FUEL
	FT.	KNOTS		LBS/HR	KNOTS		LBS/HR	W/PL			LBS/HR
1	1.0	10000.	140.0	45818.	28660.	30.0	893.	404.	30.0	893.	404.
2	1.0	5000.	129.6	43241.	27277.	30.0	993.	429.	30.0	993.	429.
3	1.0	1500.	123.0	41541.	26204.	30.0	1069.	462.	30.0	1069.	462.
4	0.8	10000.	140.0	44479.	27823.	60.4	17261.	6951.	81.2	19229.	7546.
5	0.8	5000.	129.6	42008.	26512.	56.0	15965.	6116.	75.3	18098.	6920.
6	0.8	1500.	123.0	40378.	25483.	53.2	15141.	5800.	71.6	17359.	6637.
7	0.8	10000.	140.0	40863.	23368.	39.4	5261.	2159.	53.3	6076.	2416.
8	0.8	5000.	129.6	38571.	23068.	36.6	4876.	1880.	49.5	5634.	2190.
9	0.8	1500.	123.0	37059.	22164.	34.7	4632.	1786.	47.0	5353.	2081.
10	0.8	10000.	140.0	39995.	21170.	30.0	805.	366.	30.0	805.	366.
11	0.8	5000.	129.6	37746.	22134.	30.0	892.	388.	30.0	892.	388.
12	0.8	1500.	123.0	36262.	21264.	30.0	959.	417.	30.0	959.	417.
13	0.8	10000.	140.0	39995.	21170.	30.0	805.	366.	30.0	805.	366.
14	0.8	5000.	129.6	37746.	22134.	30.0	892.	388.	30.0	892.	388.
15	0.8	1500.	123.0	36262.	21264.	30.0	959.	417.	30.0	959.	417.
16	0.6	10000.	140.0	55302.	34593.	95.3	48845.	22666.	127.8	51465.	29720.
17	0.6	5000.	129.6	52344.	33080.	88.4	46050.	26543.	118.5	48744.	29474.
18	0.6	1500.	123.0	50388.	31844.	84.0	44217.	25486.	112.6	46945.	28387.
19	0.6	10000.	140.0	44292.	17552.	79.3	30407.	11552.	106.4	32395.	12292.
20	0.6	5000.	129.6	41871.	17174.	73.5	28598.	10991.	98.7	30600.	11800.
21	0.6	1500.	123.0	40281.	16519.	69.9	27466.	10533.	93.8	29418.	11344.
22	0.6	10000.	140.0	37134.	14322.	59.5	13934.	5609.	80.0	15579.	6105.
23	0.6	5000.	129.6	35071.	13863.	55.2	12890.	4928.	74.2	14664.	5692.
24	0.6	1500.	123.0	33709.	13325.	52.5	12227.	4675.	70.6	14065.	5373.
25	0.6	10000.	140.0	33825.	12893.	30.0	2115.	840.	40.9	2459.	938.
26	0.6	5000.	129.6	31925.	12355.	30.0	1988.	769.	38.0	2292.	878.
27	0.6	1500.	123.0	30672.	11870.	30.0	1923.	744.	36.2	2185.	838.

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3-LOBED DYNASTAT "IDEALIZED"			DESIGN VMAX = 140. KNOTS			TABLE IV-105			RECIPROCATING - COMPOUND ENGINE		
W0 = 1500000. LBS			DESIGN ALTITUDE, H3 = 20000. FT								
1	2	3	4	5	6	7	8	9	10	11	12
LS/WO	H	FUEL	VMAX	BHP	FUEL	V(MIN BHP)	BHP	FUEL	V(MAX RGE)	BHP	FUEL
	FT.	FLOW	KNOTS		LBS/HR	KNOTS		LBS/HR	KNOTS		FLOW
											LBS/HR
1	1.0	W0	20000.	42015.	22619.	30.0	836.	385.	30.0	836.	385.
2	1.0	W0	10000.	37121.	15110.	30.0	1046.	463.	30.0	1046.	463.
3	1.0	W0	1500.	33501.	13636.	30.0	1261.	558.	30.0	1261.	558.
4	0.8	W0	20000.	41663.	22429.	63.5	18277.	7134.	85.4	20111.	7899.
5	0.8	W0	10000.	36880.	15024.	54.2	15497.	6186.	72.9	17697.	7039.
6	0.8	W0	1500.	33334.	13580.	47.8	13596.	5427.	64.2	15663.	6230.
7	0.8	W1	20000.	37886.	14680.	44.0	6569.	2594.	59.4	7580.	2851.
8	0.8	W1	10000.	33490.	13175.	37.6	5589.	2251.	50.8	6454.	2509.
9	0.8	W1	1500.	30237.	11895.	33.1	4920.	1981.	44.8	5684.	2210.
10	0.8	W2	20000.	36665.	14083.	30.0	755.	351.	30.0	755.	351.
11	0.8	W2	10000.	32395.	12679.	30.0	938.	420.	30.0	938.	420.
12	0.8	W2	1500.	29236.	11442.	30.0	1126.	504.	30.0	1126.	504.
13	0.8	W3	20000.	36665.	14083.	30.0	755.	351.	30.0	755.	351.
14	0.8	W3	10000.	32395.	12679.	30.0	938.	420.	30.0	938.	420.
15	0.8	W3	1500.	29236.	11442.	30.0	1126.	504.	30.0	1126.	504.
16	0.6	W0	20000.	54986.	29601.	100.2	51015.	19838.	134.4	53582.	21241.
17	0.6	W0	10000.	48917.	19972.	85.5	45056.	17778.	114.7	47785.	19311.
18	0.6	W0	1500.	44393.	18125.	75.4	40685.	16053.	101.1	43462.	17564.
19	0.6	W1	20000.	43501.	16456.	84.8	33207.	12494.	113.8	35242.	13193.
20	0.6	W1	10000.	38611.	14918.	72.3	29191.	11264.	97.1	31262.	11883.
21	0.6	W1	1500.	34976.	13513.	63.8	25772.	9944.	85.6	28324.	10767.
22	0.6	W2	20000.	35677.	13341.	66.2	17243.	6866.	89.0	18781.	7293.
23	0.6	W2	10000.	31590.	11989.	56.5	14622.	5751.	75.9	16547.	6525.
24	0.6	W2	1500.	28560.	10839.	49.8	12830.	5047.	66.9	14782.	5829.
25	0.6	W3	20000.	31512.	12051.	40.5	4420.	1748.	54.9	5110.	1923.
26	0.6	W3	10000.	27853.	10884.	34.6	3771.	1520.	47.0	4363.	1697.
27	0.6	W3	1500.	25145.	9826.	30.5	3328.	1341.	41.5	3853.	1498.

SECTION V - STRUCTURAL AND WEIGHT CONSIDERATIONS

List of Specific Stress Symbols

A	cross-sectional area of DYNASTAT
A	πr^2
a	$\frac{5r\theta F_{tu}}{6n_H \gamma E}$
a_z	vertical transverse acceleration
A, B, C	coefficients
b	$\frac{5n_B M}{3\gamma E \pi r}$
b	span of fins
C_{L_α}	slope of C_L vs. α curve
$C_{L_{\alpha eff}}$	effective C_{L_α} in a gust
C_p	pressure coefficient
c	distance from neutral axis to outer fiber of beam
c	$\rho_g - \rho$
\bar{c}	fin mean chord
d	airship maximum depth
d_{AVG}	average depth
E	modulus of elasticity
F	force
F_d	critical stress cause dimpling of the face sheet across a cell
F_t	tail load
F_{tu}	tensile ultimate material strength
f_{co}	hoop tension in external wall of an outer cell
f_i	vertical tension in web between two inner cells
f_{ie}	hoop tension in external wall of an inner cell
f_{oi}	vertical tension in web between an inner and an outer cell

G_c	shearing modulus of elasticity of core
g	acceleration of gravity
h	sandwich thickness; $t_c + 2t_f$
I	moment of inertia of cross-section
k	$0.029 \left(\frac{L_r}{2}\right)^{1/4}$
k	reduction factor related to the shear stiffness of the core; $\frac{N}{N_o}$ in reference 29.
k_t	additional mass coefficient for the tail
k_3	transverse additional mass coefficient
k_{3b}	same for body alone
k_{3t}	$k_3 - k_{3b}$
k	airship mass/ ρV
L	airship length
L_d	dynamic lift
L_r	1000 ft., an arbitrary length of reference
L_s	airship static lift
L_t	F_{tu}/w_f ; length of material hung vertically which will break of its own weight
M	bending moment
M_B	buckling moment
M_C	collapse moment
M_{cr}	critical moment (may be = M_B or M_C)
$M_{cr(p)}$	critical moment with internal pressurization
M_g	maximum gust moment
$M_p = 0$	$\sigma_{XBO} \pi r^3 t$
M_{wr}	bending moment just sufficient to reduce stress to zero on one side of an inflated member; moment to cause incipient wrinkling

m	mass
m _a	additional mass
N _H	fabric hoop tension
N _L	fabric longitudinal tension
n	number of inner cells in a DYNASTAT
n _B	M _B /M
n _g	gust load safety factor
n _H	safety factor for hoop tension
n _L	safety factor for longitudinal tension
n _Z	vertical load factor $\frac{a_z}{g} + 1$
p	inflation pressure (gage)
q	$\frac{1}{2} \rho v^2$
\bar{q}	$\rho u v$, effective dynamic pressure
q _o	increment in shear flow per unit length of the envelope
r	radius
r _i	radius of inner cells of DYNASTAT
r _o	radius of outer cells of DYNASTAT
S	equivalent cross-sectional area/t
s	honeycomb core cell size
t	thickness of skin
t _c	core thickness
t _{ei}	effective thickness of web between inner and outer cell
t _f	face thickness
u	gust velocity
V	velocity
V	airship displacement volume
v _g	gust velocity
W	total weight (in a vacuum)

W	airship maximum width
W_{AVG}	average width
W_o	gross weight
w	weight per unit area
w_B	adhesive weight per unit area
w_C	core weight per unit area
w_F	face sheet weight per unit area
w_f	weight per unit area of fabric
w_s	total unit sandwich weight per unit area
X	abscissa
Z	vertical ordinate
α	angle of attack
α_b	arc tan $v_b/$
α_n	normal angle of attack in flight
β	half the angle swept out by one external wall of an inner cell
γ	$1 - 0.731 (1 - e^{-\phi})$; a correlation factor accounting for the difference between theory and test
η	Ψ/AL
θ	half the angle swept out by one external wall of an outer cell
ϕ	reduction factor to allow for the effect of fasteners
μ	Poisson's ratio
ξ	$\frac{2n_B n_H}{\theta F_{t_u}}$
ρ	density of air surrounding the airship
ρ_{AL}	density of aluminum alloy
ρ_C	core density
ρ_f	face density

ρ_g density of lifting gas

σ_{CR} buckling stress

σ_{XBO} buckling stress at zero pressure

ϕ $\frac{1}{16} \sqrt{\frac{r}{t}}$

ϕ $\frac{\sqrt{2}}{29.8} \sqrt{\frac{r}{h}}$; also angle defining point on the envelope

ω $\frac{\sigma F_{t_u}}{n_H r}$

1. DYNASTAT ANALYSIS

a. Introduction

Analysis of dynamic-lift airship configurations presents some problems that do not occur in considering the conventional airships. First, the bending moments in the conventional airships are estimated from a semi-empirical formula which is quite obviously inapplicable to a DYNASTAT configuration. Pressure distributions from wind-tunnel tests of a specific class of dynamic lift configurations at two angles of attack - 10° and 20° - is available, however, as well as sufficient information to establish a relationship between the airship heaviness and its angle of attack in ordinary level flight. The critical condition is taken to be a vertical gust condition, and accelerations are calculated from Newton's law, where the gust force is

$$F = q C_{L_{\alpha_{eff}}} \psi^{2/3}$$

The mass accelerated must include the "additional mass" of air associated with the airship, which can be estimated from the principles originally stated by Lamb and put into an applicable form by Tuckerman (Ref. 25) for ellipsoids. These factors are based on specific sizes, but are non-dimensionalized to apply to any size.

The accelerations obviously depend on $C_{L_{\alpha_{eff}}}$. In the design of conventional airships, the slope of the lift coefficient vs. angle of attack curve, $C_{L_{\alpha}}$, has long been taken as

$$C_{L_{eff}} = 2 C_{L_{\alpha}} = \frac{2}{\alpha} \arctan \frac{v_g}{V}$$

and this was assumed at first to be applicable to DYNASTATS, and initial values were obtained on this basis. The effective angle of attack is greater than $\arctan v_g/V$ because the airship is pitched through a "space angle" as it enters the gust by the load on its forward part.

In the present analysis, no rotation of the airship is assumed, for the sake of simplicity of analysis, and equilibrium is obtained by adjusting the tail load. This is known to be a severe condition since it implies that the pilot is fighting the gust, and it results in high tail loads. Good pilot technique would allow the airship to ride with the gust. The resisting inertia forces are distributed quite differently when the airship is rotating about a pitch or yaw axis than when it is simply translating. If, however, the airship motion is limited to translation, the increase in effective angle of attack will not occur.

Furthermore, because of the smaller tail loads and the different distribution of inertia forces, the point of maximum bending moment will move forward, nearer to the maximum section where pressure requirements for a given bending moment are correspondingly smaller.

The increased complexity of the calculations when pitching is allowed for is prohibitive within the limited scope of the present investigation. To arrive at a more realistic design condition, the factor of 2 which makes $C_{L_{\alpha_{eff}}} = 2C_{L_{\alpha}}$ was re-examined. It is based on gust-tunnel measurements at Daniel Guggenheim Airship Institute (Ref. 28) in the early 1940's on a model of the rigid airship Akron. In general, α_{eff} was much less than 2α , but with control surfaces of two designs of three investigated, and with them deflected to -10° (up elevator), α_{eff} was found to be greater than 2α in one test and nearly 2α in another. To hold the airship horizontal, however, against an up gust, the pilot would have to use down elevator, and for all such cases, α_{eff} was less than $\alpha = \arctan v_g/V$.

Without additional work in a gust tunnel, values for configurations other than the Akron configurations tested remain somewhat speculative, even for such conventional types as the Navy "blimps", and for the DYNASTAT much more so. However, comparisons with airplane wings, which the DYNASTAT approaches, indicate a lower maximum $C_{L_{\alpha_{eff}}}$ should be expected.

In view of all these considerations, and in particular those concerning elevator attitude, the results using $C_{L_{eff}} = 2C_{L_{oc}}$ are doubly and unduly conservative, and in fact to put $C_{L_{eff}} = C_{L_{oc}}$ is still conservative. Load factors from the initial analysis should be reduced as follows:

$$n_Z = \frac{n_{Z_o} + 1}{2}$$

The effect of this on stress and weight is shown by two graphs (Figures 38 and 39) which show that for $n_{Z_o} > 1.25$, the weights of the 5-lobe DYNASTAT are about 55% of the original calculated values.

b. Assumptions

1. The 5-lobe DYNASTAT configuration of Drg. 67QS977, Figure 7 is assumed, and the 3-lobe of Drg. 67QS1644, Figure 6, but the 7-lobe is estimated from the 3- and 5-lobe configuration drawings and Reference 23.
2. The additional mass of the DYNASTAT is calculated from the assumption that it is an ellipsoid.
3. Tail additional masses are estimated for a rectangular flat plate of the same area, as suggested by Reference 24.
4. It is assumed that the DYNASTATS, upon entering a gust, do not rotate, being held in rotational equilibrium by a vertical tail load.
5. $C_{L_{eff}} = \arctan v_g/V$

Because the same or equivalent assumptions were not made for the conventional airship, the comparison is not entirely valid. It is probable that the analysis results (weights) for the DYNASTAT are more conservative than those for the conventional airship, but only a more detailed examination of the assumptions, and appropriate experimental configurations, can clarify this point.

c. Additional Mass Coefficients

Table V-1 shows dimensions of specific configurations from Reference 23, and calculation of equivalent ellipsoid dimensions according to Reference 24. The additional mass factors for the body alone may be obtained from the equations given in Reference 25, or in some cases, from data in Reference 24. The final column comes from Table V-2.

TABLE V-1

DYNASTAT SHAPE FACTORS

$$\Psi = 975,000 \text{ cu. ft.}$$

No. Lobes	Length L, ft.	Actual Width W, ft.	Actual Depth d, ft.	L/W_{avg}	L/d_{avg}	$\frac{W_{\text{avg}}}{d_{\text{avg}}}$	$\frac{L}{d_{\text{avg}}} \sqrt{\frac{\pi}{6}} = .725 \frac{L}{d_{\text{avg}}}$	k_3 (body alone)	k_3 With Tail
1 (Conv)	342.65	75.42	75.42	5.70	5.70	1.0	4.13	.86	.93
2	...	...	...	...	...	...	...	...	...
3	324.5	102.1	76.1	4.17	6.067	1.455	4.40	1.24	1.30
4	272	114	63.8	2.89	6.067	2.10	4.40	1.62	1.71
5	248	130	58.2	2.20	6.067	2.76	4.40	1.96	2.08
6	230.5	144.9	54.1	1.80	6.067	3.37	4.40	2.24	2.38
7	222	162.8	52.1	1.51	6.067	4.02	4.40	2.50	2.65

Table V-2 is based on drawings 67QS977, Figure 7, and 67QS1 644, Figure 6, Reference 23, and Reference 24. After k_t is obtained, it is referred to the airship dimensions instead of the tail dimensions so that it can be added to k_3 in a general way for parametric considerations. The 4- and 6-lobe values with tail in Table VI-1 are obtained by interpolation in Figure 30.

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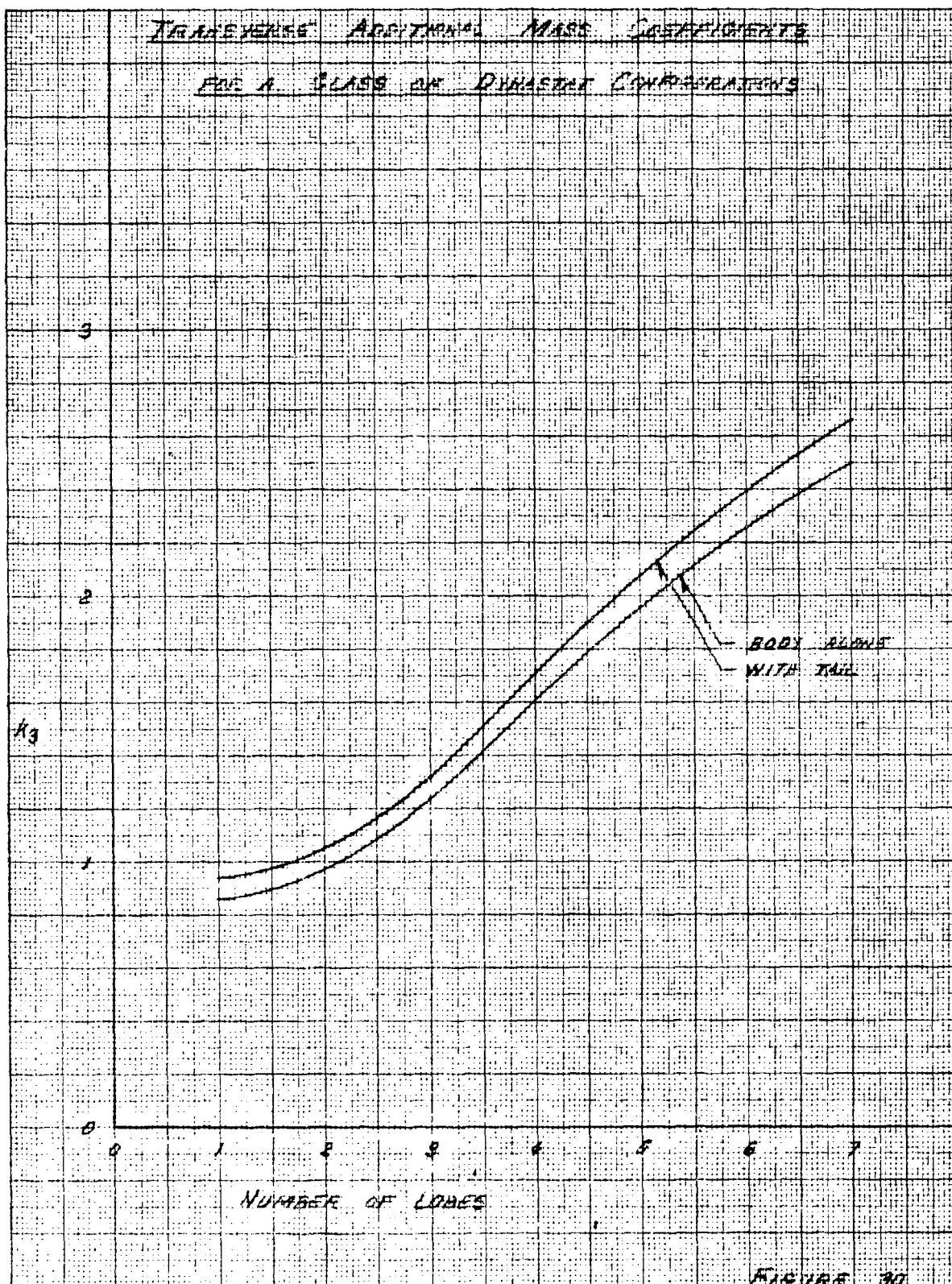


TABLE V-2

EMPENNAGE ADDITIONAL MASS FACTORS*

Airship Vol. cu. ft. Ψ	No. Lobes	b_{eff}	\bar{c} (assume const.)	\bar{c}^{-2}	$\bar{c}^{-2}b$	$\frac{b}{\bar{c}} = AR$	k_t	$k_t \bar{c}^{-2}b$
975,000	1	77.9	45.8	2100	165,500	1.70	.72	117,500
8,550,000	3	179	80	6400	1,140,000	2.24	.79	900,000
8,550,000	5	265	80	6400	1,690,000	3.31	.87	1,470,000
8,550,000	7	330	80	6400	2,110,000	4.12	.91	1,920,000

Airship Vol. cu. ft. Ψ	$k_t \bar{c}^{-2}b(975,000)$ Ψ	$k_3 LW_{avg} d_{avg} \left(\frac{4}{\pi}\right)$	$\frac{k_t \bar{c}^{-2}b\pi}{4k_3 LW_{avg} d_{avg}}$	k_{3b} (body alone)	k_3 With Tail	k_{3t}
975,000	117,500	1,360,000	.0863	.86	.93	.07
8,550,000	102,600	2,110,000	.0487	1.24	1.30	.06
8,550,000	167,700	2,830,000	.0593	1.96	2.08	.12
8,550,000	218,500	3,760,000	.0582	2.50	2.65	.15

* For the empennage

$$m_{a_i} = \frac{\pi \rho}{4} k_t \bar{c}^{-2} b$$

where \bar{c} is the mean chord of the fin, b is the span, and k_t is the coefficient of additional mass for the tail. It is obtained from Reference 24, Figure ..

d. Load Factors

The normal load factor in the vertical direction is defined as

$$n = 1 + \frac{a_z}{g} \quad (1)$$

where g is the acceleration of gravity and (for a neutrally buoyant airship)

$$a_z = \frac{F}{m} = \frac{\frac{\rho}{2} V^2 C_{L_{\bar{c}}} \Psi^{2/3}}{\rho \Psi (1 + k_3)} \quad (2)$$

$$a_z = \frac{C_{L_{\bar{c}}} V^2}{2 \Psi^{1/3} (1 + k_3) g}$$

TABLE V-3

EFFECTIVE LIFT SLOPE COEFFICIENTS

No. Lobes	$C_{L_{\infty}}$ 1/deg up to 10° With Tail	$C_{L_{\infty}}$ 1/deg at 10° (Body Alone)	$C_{L_{\infty}}$ With Tail (rad)	$C_{L_{\infty}}$ (Body Alone)	$C_{L_{\infty}}(eff)^*$
1	.0140	.0025	.801	.143	1.60
3	.0190	.0080	1.086	.458	2.17
5	.0395	.0242	2.26	1.385	4.52
7	. . .	.0460	4.0 (extra- polated)	2.63	8.0

* Experimental data from DGAI tests (Reference 28) show that the effective angle of attack can be approximately twice the actual angle, so $C_{L_{\infty}}$ is effectively twice as great (see introduction to this section, page 158).

The effect of aspect ratio on the lift-slope coefficient, which is proportional to the accelerations the DYNASTATS will experience in gusts, is shown in Figure 31.

Table V-4 shows calculated load factors for the various configurations, assuming 30 fps gusts, at various airship velocities, assuming neutral buoyancy. The results are plotted in Figure 32.

e. Airships Flying Heavy

A neutrally buoyant airship in level flight would fly at zero angle of attack. An airship flying heavy would fly at some positive angle of attack. The effect of a gust is to change the angle of attack, and the transverse g's are proportional to the change, which is independent of the initial angle of attack. Heaviness thus has no effect on $C_{L_{\infty}}$.

Transverse accelerations are inversely proportional, however, to the virtual mass of the airship, which is the sum of the actual mass and the additional mass of associated air. When the airship is neutrally buoyant,

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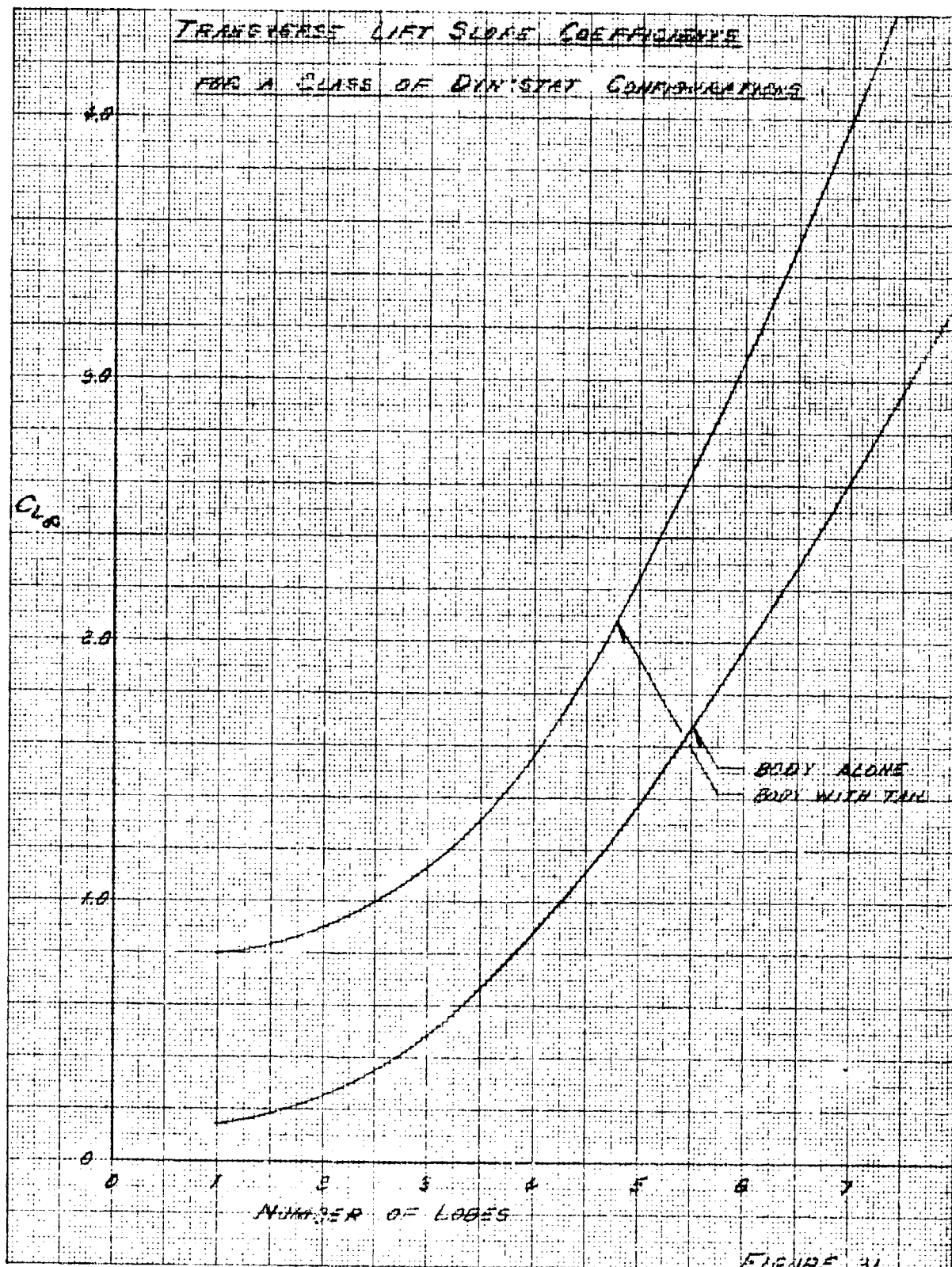


FIGURE 31

TABLE V-4

LOAD FACTORS FOR 30 FPS GUSTS IF $C_{L_{eff}} = 2C_{L_c}$
(NEUTRALLY BUOYANT AIRSHIPS)

Ψ ft ³	V fps	$\Psi^{1/3}$ ft	No. Lobes				
			(1 Lobe)	1	3	5	7
			$\frac{a_z}{g}$	n_z	n_z	n_z	n_z
10^5	118	46.5	.98	1.98	2.12	2.74	3.59
	236	46.5	1.96	2.96	3.23	4.58	6.18
	354	46.5	2.94	3.94	4.35	6.32	8.77
10^6	118	100	.46	1.46	1.52	1.81	2.20
	236	100	.91	1.91	2.04	2.62	3.40
	354	100	1.37	2.37	2.56	3.43	4.60
10^7	118	215	.21	1.21	1.24	1.37	1.56
	236	215	.41	1.41	1.48	1.75	2.12
	354	215	.63	1.63	1.72	2.12	2.67
10^8	118	465	.10	1.10	1.11	1.17	1.26
	256	465	.20	1.20	1.22	1.35	1.52
	354	465	.29	1.29	1.33	1.52	1.78

the actual mass is $\rho\Psi$, but if the airship is flying heavy, the actual mass is greater than $\rho\Psi$, although the additional mass is unchanged. If the additional mass is $k_3\rho\Psi$, and the airship is k_4 times as heavy as the surrounding air, the effective or virtual mass is $(k_3 + k_4)\rho\Psi$, and

$$a_z = \frac{C_{L_{eff}} \frac{v}{g} V}{2\Psi^{1/3}(k_4 + k_3)} \quad (3)$$

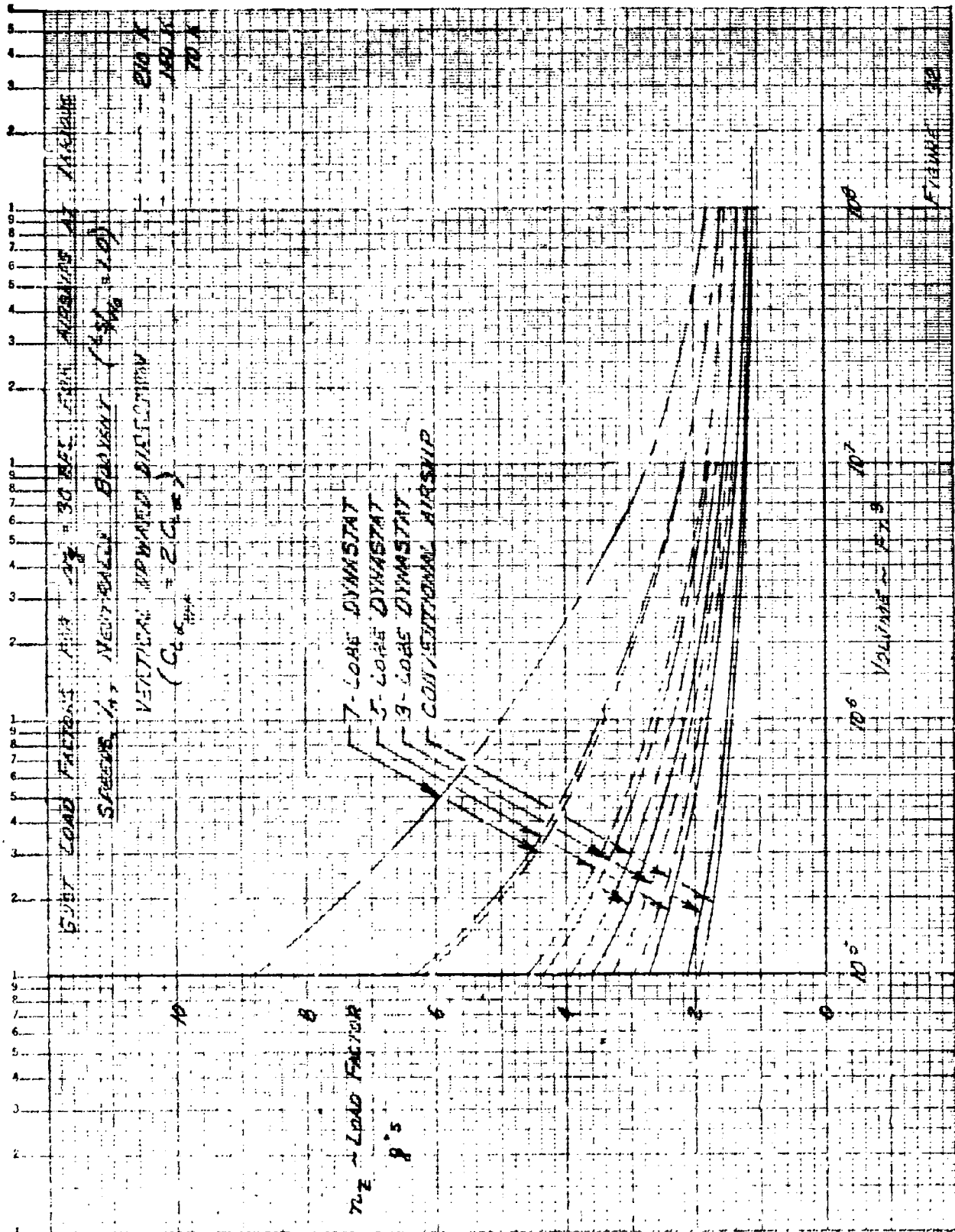
A "20% heavy" airship is defined here as one which carries 20% of its gross weight dynamically. The "gross weight" W_o , is defined as the weight of the airship minus lifting gas. The weight of helium at standard conditions is assumed to be 0.015 lb/ft³, and that of standard air 0.0765

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lb/ft³ (ρ_a). If W_o is the gross weight,

$$.80 W_o = (.0765 - .013) \Psi = .0635 \Psi$$

or

$$W_o = \frac{.0635}{.0765} \left(\frac{1}{.80} \right) \Psi$$

$$W_o = 1.037 \Psi$$

The total weight,

$$W = .013 \Psi + W_o = \frac{.013}{.0765} \Psi + W_o$$

$$= .170 \Psi + 1.037 \Psi$$

$$= 1.207 \Psi \approx 1.21 \Psi$$

For 40% heavy,

$$W_o = \frac{.0635}{.0765} \left(\frac{1}{.6} \right) \Psi = 1.380 \Psi$$

$$W = .170 \Psi + 1.380 \Psi$$

$$= 1.550 \Psi$$

if $k_4 = \frac{W}{\Psi}$, then

$$k_4 = 1.21 \text{ for } 20\% \text{ heavy airships}$$

$$1.55 \text{ for } 40\% \text{ heavy airships}$$

$$[\text{for } 10\% \text{ heavy, } k_4 = .921 + .170 = 1.09]$$

The air density/helium density ratio is assumed independent of altitude. Resulting virtual mass coefficients are given in Table V-5. Gust load factors are calculated in Table V-6 and plotted in Figure 33.

If the ratio of the lifting gas density to that of the surrounding air is assumed constant, then the relationships between speed, heaviness, angle of attack, and volume are independent of altitude. The relationships for the 5-lobe DYNASTAT configuration used in the present study are shown in Figure 34. However, the difference between rigid and non-rigid volumes (6.5%) is here ignored as unimportant when Figure 34 is used for subsequent calculations.

TABLE V-5
VIRTUAL MASS COEFFICIENTS ($k_4 + k_3$)

No. Lobes	k_3	Neutrally Buoyant $k_4 = 1.00$	20% Heavy $k_4 = 1.21$	40% Heavy $k_4 = 1.55$
1	.93	1.93	2.14	2.48
3	1.30	2.30	2.51	2.85
5	2.08	3.08	3.29	3.63
7	2.65	3.65	3.86	4.20

A 30 fps gust corresponds to the following angles of attack:

At	70 knots,	$\alpha_g = 14.2^\circ$
	105 knots,	$\alpha_g = 9.6^\circ$
	140 knots,	$\alpha_g = 7.25^\circ$
	210 knots,	$\alpha_g = 5.85^\circ$

If the airship is neutrally buoyant, $\alpha_o = 0$ and $\alpha = \alpha_g + \alpha_o = \alpha_g$; but if the airship is heavy, α_o corresponds to a given % heaviness, airship speed, volume, and (for DYNASTATS) number of lobes.

Pressure distributions are available for this configuration, reduced from Reference 3 and 4. These have been integrated spanwise to obtain chord-wise (longitudinal) load distributions. At zero angle of attack, aerodynamic bending moments are zero.

For a given aerodynamic pressure distribution, mass distribution, and L_s/W_o , the bending moment at a given station is a linear function of the acceleration:

$$\frac{dM}{da_z} = \text{const.}$$

The maximum moment for $a_z = 0$, for instance, may occur at a different station from that for large values of a_z , however.

Two representative load factors are assumed for preliminary analysis: $n_z = 1.7$ g's and $n_z = 1.0$ g's. Since moments and weights are proportional to n_z , final results will be obtained by interpolation.

TABLE V-6
GUST LOAD FACTORS FOR HEAVY AIRSHIPS

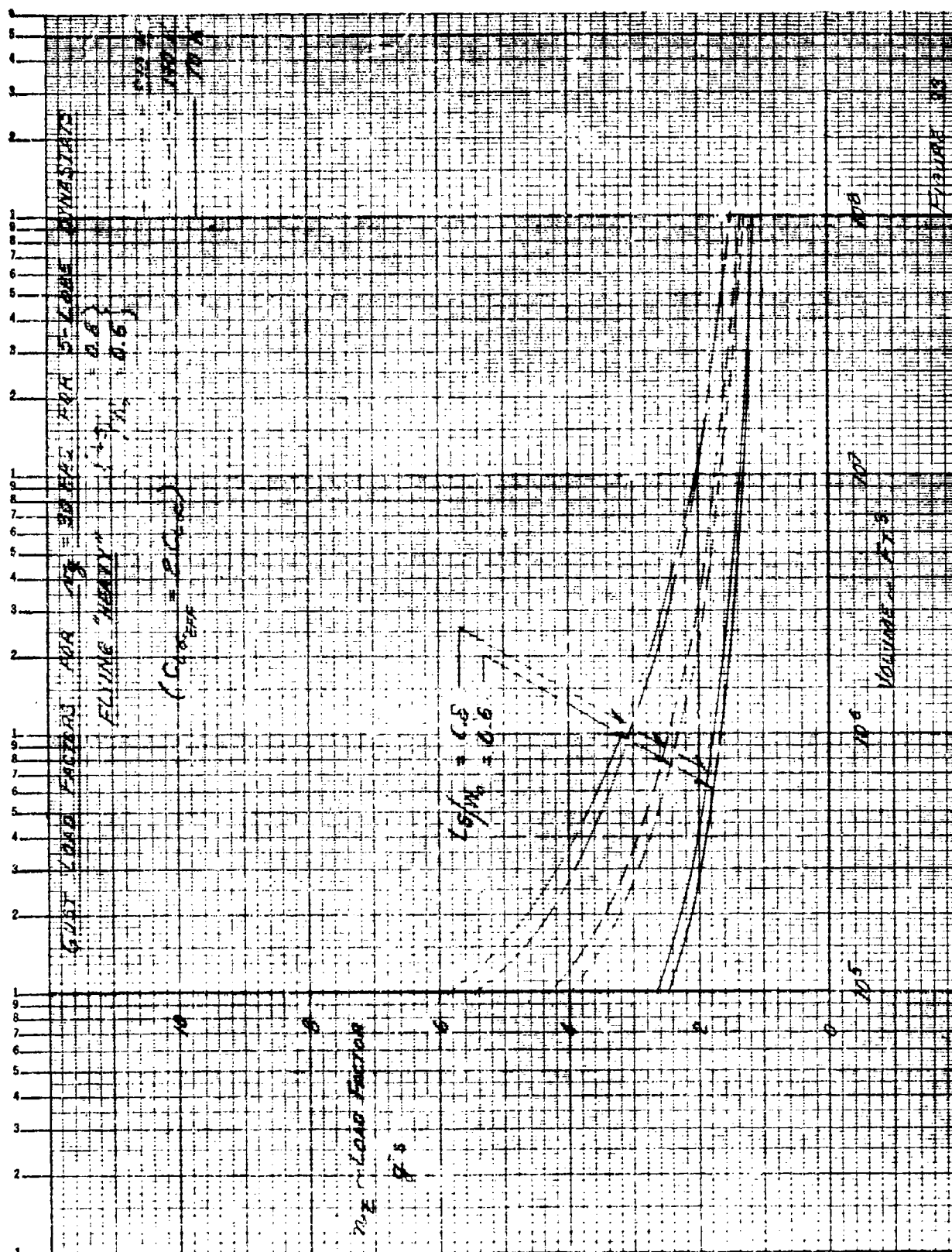
$$(C_{L_{eff}} = 2C_L)$$

			$1 + a_z/g; V_k = 70 \text{ knots}; v_g = 30 \text{ fps}$									
			$\frac{C_{L_{\text{eff}}}}{k_4 + k_3}$		20% Heavy		40% Heavy					
No. Lobes	$C_{L_{\text{eff}}}$		20% Heavy	40% Heavy	$V = 10^5 \text{ ft}^3$	$V = 10^6 \text{ ft}^3$	$V = 10^7 \text{ ft}^3$	$V = 10^8 \text{ ft}^3$				
1	1.60		.748	.645	1.88	1.41	1.19	1.09	1.76	1.35	1.16	1.08
3	2.17		.864	.761	2.02	1.47	1.22	1.10	1.90	1.42	1.19	1.09
5	4.52		1.37	1.245	2.62	1.75	1.35	1.16	2.47	1.68	1.32	1.15
7	8.0		2.07	1.90	3.45	2.14	1.53	1.25	3.22	2.04	1.48	1.22

$V_k = 140 \text{ knots}, v_g = 30 \text{ fps}$												
1	1.60		.748	.645	2.76	1.82	1.38	1.18	2.53	1.71	1.33	1.15
3	2.17		.864	.761	3.05	1.95	1.44	1.21	2.81	1.84	1.39	1.18
5	4.52		1.37	1.245	4.25	2.51	1.70	1.33	3.95	2.37	1.64	1.30
7	8.0		2.07	1.90	5.91	3.28	2.06	1.49	5.48	3.08	1.96	1.45

$V_k = 210 \text{ knots}, v_g = 30 \text{ fps}$												
5	4.52		1.37	1.245	5.87	3.26	2.05	1.49	5.42	3.05	1.96	1.45

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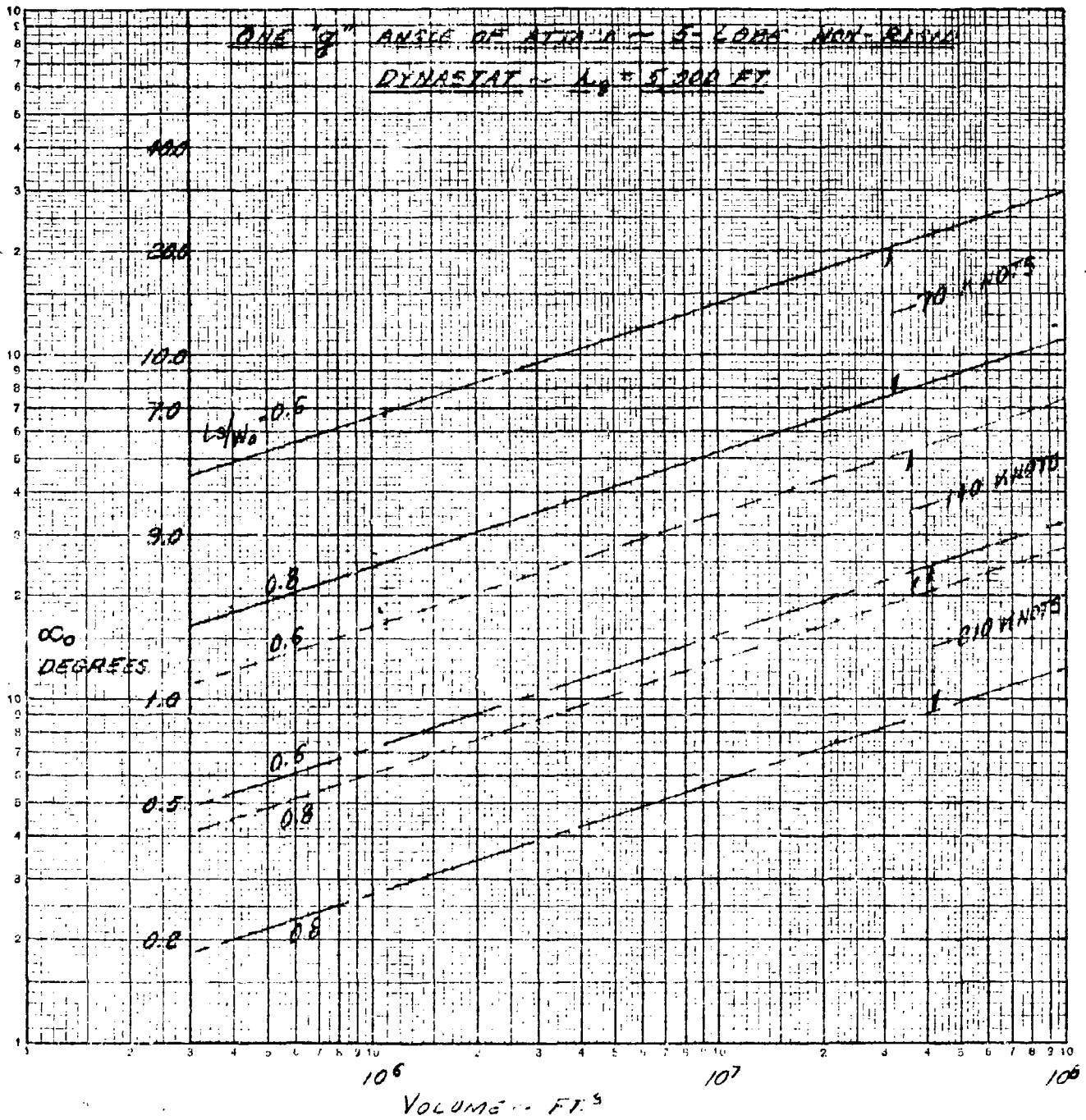


FIGURE 34

TABLE V-7

CROSS-SECTIONAL AREAS AND V

(L = 25.55 = 511 ft)

Sta.	r_i (From Drg.)	r_i/L	L/r_i	$\sin \beta = .0525 \frac{L}{r_i}$	β°	$\sin 2\beta$	$\frac{r_i^2}{L^2}$	β rad	$\frac{r_i^2}{L^2} \beta$	$\frac{r_i^2}{L^2} \sin 2\beta$
0	...	...	...	...	...	...	...	...	...	...
.1	2.25	.0880	11.34	.595	36.5	.956	.00775	.637	.00494	.00740
.2	2.75	.1075	9.28	.487	29.15	.852	.01157	.509	.00589	.00985
.3	3.00	.1174	8.51	.447	26.5	.799	.01379	.463	.00638	.01088
.4	2.95	.1155	8.66	.455	27.1	.811	.01332	.472	.00629	.01080
.5	2.73	.1068	9.35	.490	29.35	.854	.01140	.512	.00583	.00974
.6	2.33	.0912	10.96	.577	35.2	.942	.00832	.615	.00512	.00783
.7	1.92	.0752	13.31	.700	44.5	1.000	.00565	.775	.00438	.00565
.8	1.55	.0607	16.47	.866	60.0	.866	.00368	1.047	.00384	.00319
.9	0.95	.0372	26.9	gas cells end at 84%	...	...	.00138	...	...	...
1.0	0	0	∞

* The remaining volume of $1.000 - .9944 = .0066$ must be distributed at the nose and tail. Ass

A

TABLE V-7

L AREAS AND VOLUME DISTRIBUTION

$\frac{r_i^2}{L^2} \beta$	$\frac{r_i^2}{L^2} \sin^2 \beta$	$\frac{3r_i^2}{L^2} \sin^2 \beta$	$\frac{6r_i^2}{L^2} \beta$	$\cos \beta$	$\frac{r_i}{L} \cos \beta$	$\frac{r_i^2}{L^2} \cos^2 \beta$	$\frac{\pi r_i^2}{L^2} \cos^2 \beta$	$\frac{A}{L^2}$	$1563 \frac{A}{L^2} = \frac{\Delta V}{V}$
...	...	...	...	...	...	...	...	...	(.0060)*
.00494	.00740	.0222	.0296	.804	.0708	.00501	.01574	.0675	.1053
.00589	.00985	.0295	.0353	.873	.0939	.00882	.02770	.1025	.1602
.00638	.01088	.0326	.0383	.895	.1050	.01103	.03465	.1056	.1650
.00629	.01080	.0324	.0377	.890	.1029	.01059	.03325	.1034	.1616
.00583	.00974	.0292	.0350	.872	.0930	.00866	.02720	.1014	.1585
.00512	.00783	.0235	.0307	.817	.0745	.00555	.01742	.0716	.1118
.00438	.00565	.01695	.0263	.714	.0537	.00288	.00905	.0490	.0765
.00384	.00319	.00957	.0230	.500	.0303	.00092	.00288	.0355	.0555
...	...	...	...	...	...	...	...	...	(.0006)*
...	...	...	...	...	...	...	...	...	0
									.9944*

nose and tail. Assume .0006 at Sta. 9 and .0060 at Sta. 0 (based on Drg. 57QS977).

B

With an estimated mass distribution, the bending moment due to airship weight and acceleration can be found. The additional mass will be assumed to be distributed as the volume is; i.e., the cross-sectional area, except that due to the tail will be assumed to be at the tail.

For any cross-section (Reference 23) having n inner cells, the cross-sectional area is

$$A = r_o^2 (2\theta - \sin 2\theta) + 2nr_i^2 \beta + nr_i^2 \sin 2\beta \quad (4)$$

where θ and β are half the angles swept out by one external wall of an outer and an inner cell, respectively. If the outer cells are semi-circular in cross-section, $\theta = \pi/2$, and for a 5-lobe DYNASTAT, $n = 3$. Then

$$A = \pi r_o^2 + 6r_i^2 \beta + 3r_i^2 \sin 2\beta \quad (4a)$$

The angle β varies along the length of the DYNASTAT since the center cells are of constant width.

$$2r_i \sin \beta = \text{cell width} \quad (5)$$

Since the chosen typical configuration has a width of .315L at nose and tail, one cell has a width of .105L:

$$\begin{aligned} 2r_i \sin \beta &= .105L \\ \sin \beta &= .0525 \frac{L}{r_i} \end{aligned}$$

$$\frac{L}{V^{1/3}} = \frac{511}{(8,550,000)^{1/3}} = \frac{511}{204.5} = 2.50$$

The volume of any 10% length would be

$$\Delta V = .10LA = .250V^{1/3} \frac{AL^2}{L^2} = .250V^{1/3} (2.50V^{1/3})^2$$

$$\frac{\Delta V}{V} = 1.563 \left(\frac{A}{L^2} \right)$$

The additional mass is $k_3 \rho(\Delta V)$ but the airship mass segment is $k_4 \rho(\Delta V)$ only if its mass is uniformly distributed through the volume. Given a section mass equal to k_5 times the average mass (k_4 having already accounted for heaviness), the local g-mass is:

$$gm = k_5 k_4 \rho_a (\Delta V) \quad (6)$$

and the load due to an acceleration a_z is

$$F_1 = k_5 k_4 \frac{a_z}{g} \rho_a (\Delta V) \quad (7)$$

to which must be added the effect of the additional mass,

$$F_2 = k_3 \frac{a_z}{g} \rho_a (\Delta V) \quad (8)$$

where k_{3b} is k_3 for the body alone. For the tail, an associated additional mass coefficient can be used:

$$k_3 - k_{3b} = k_{3t} \quad (9)$$

so that a load

$$F_{t2} = k_{3t} \frac{a_z}{g} \rho_a V \quad (10)$$

must be added at the tail. If this load is divided between two sections, assume F_{t2} beamed between their centroids.

Consider a 5-lobe DYNASTAT, when $\alpha = 20^\circ$, $(1 + a_z/g) = 1.7$. If $L_s/W_o = .60$, $k_4 = 1.55$ and $k_3 = 2.08$ with tail, or $k_{3b} = 1.96$ and $k_{3t} = .12$. Given the distribution of the gross weight, and of the cross-sectional area, the inertia force distribution can be found. The sum of the inertia forces must equal the sum of the aerodynamic and buoyant lift forces. The value of q can be found from this fact:

$$q = \frac{(1 + \frac{a_z}{g}) \frac{m}{\rho_a V} - \frac{(\rho_a - \rho_g)}{\rho_a} + \frac{a_z}{g} \frac{m_a}{\rho_a V}}{\sum C_p \frac{b \Delta L}{L^2} + \frac{F_t}{\rho_a V}} \quad (11)$$

F_t being the tail load, m airship mass, and m_a additional mass.

Calculations are carried out in Table V-7 using dimensions from Drg. 67QS977, Figure 7, to get the volume distribution.

TABLE V-8
MASS DISTRIBUTION

$$L_s/W_o = .60$$

Sta.	$\frac{\Delta V}{V}$	$\frac{\Delta V}{V}$	% W _o	$\frac{\% W_o}{100 \frac{\Delta V}{V}} =$ 0.138 (% W _o)	$.170 \frac{\Delta V}{V}$	$\frac{\Delta m}{m}$	Add'l Mass/ $\frac{\Delta V}{V}$ = $1.96 \frac{\Delta V}{V}$	Tail Add'l M/ $\frac{\Delta V}{V}$	Total $\frac{\Delta m}{m}$
0	.0060								
.1	.1053	.0577	9.2	.1268	.0098	.137	.113	...	.250
.2	.1602	.1328	9.9	.1365	.0226	.159	.260	...	.419
.3	.1650	.1626	16.9	.233	.0276	.261	.319	...	.580
.4	.1616	.1633	26.3	.363	.0278	.391	.320	...	.711
.5	.1585	.1600	14.4	.1986	.0272	.226	.313	...	.539
.6	.1118	.1352	8.6	.1186	.0230	.142	.265	...	.407
.7	.0765	.0941	8.5	.1173	.0160	.133	.184	...	.317
.8	.0555	.0660	2.1	.0290	.0112	.040	.129	...	.169
.9	.0006	.0280	2.5	.0344	.0048	.039	.055	.034	.128
1.0	0	.0003	1.6	.0221	.0001	.022	.001	.086	.109
						1.550	1.959	.120	3.629

Figure 35 is obtained by integrating pressure distribution measured on a 5-lobe DYNASTAT model (minus empennage) in the University of Detroit wind tunnel in 1953, at 20° and 10° angles of attack.

In Tables V-9 and V-10, the pressure coefficients, C_p , are taken from Figure 35 and multiplied by the appropriate areas (Reference 23, p. 45) to

get $\frac{C_{pb} \Delta L}{L^2}$. This is then multiplied by q , which must be just large enough to give a resultant force equal to the net static down force on the airship after a tail load sufficient to produce rotational equilibrium has been allowed for. This tail load is always assumed to act at Sta. 90. Since the loads have been assigned generally to stations 5, 15, 25, etc., the tail load is therefore divided equally between stations 85 and 95.

In Table V-10, the buoyant lift on the airship and its additional mass is found for each 10% segment; then 1.7 g's times the segment's mass is added and moments about the nose found. Balancing these and the aerodynamic forces and moments determines the unknowns q and F_t , which are used to complete Table V-9 and calculate loads, shears, and bending moments in Table V-10. All values are non-dimensionalized for generality.

Similar calculations are carried out in Tables V-11 and V-12 for $L_s/W_o = .60$, $n_z = 1.7$, and $\alpha = 10^\circ$. The mass distribution is the same as before, but since the air load distribution is different, different magnitudes are dealt with.

If L_s/W_o changes, there is a change in the mass distribution because W_o is a different fraction of ρV . Tables V-13 and V-14 give the results for $L_s/W_o = 0.80$ and 1.00 .

The air load distribution is a function of angle of attack only, except for the tail load. In Table V-15, the column from Table V-12 headed " $\frac{C_{pb} \Delta L}{L}$ " is used together with the mass distribution from Table V-13 to get the bending moment for $L_s/W_o = .80$, $\alpha = 10^\circ$, $n_z = 1.7$ g's, while in Table V-16, values from Tables V-12 and V-14 have been similarly used; in Table V-17, values from Tables V-16 and V-9 are used; and in Table V-18, values from Tables V-15 and V-9.

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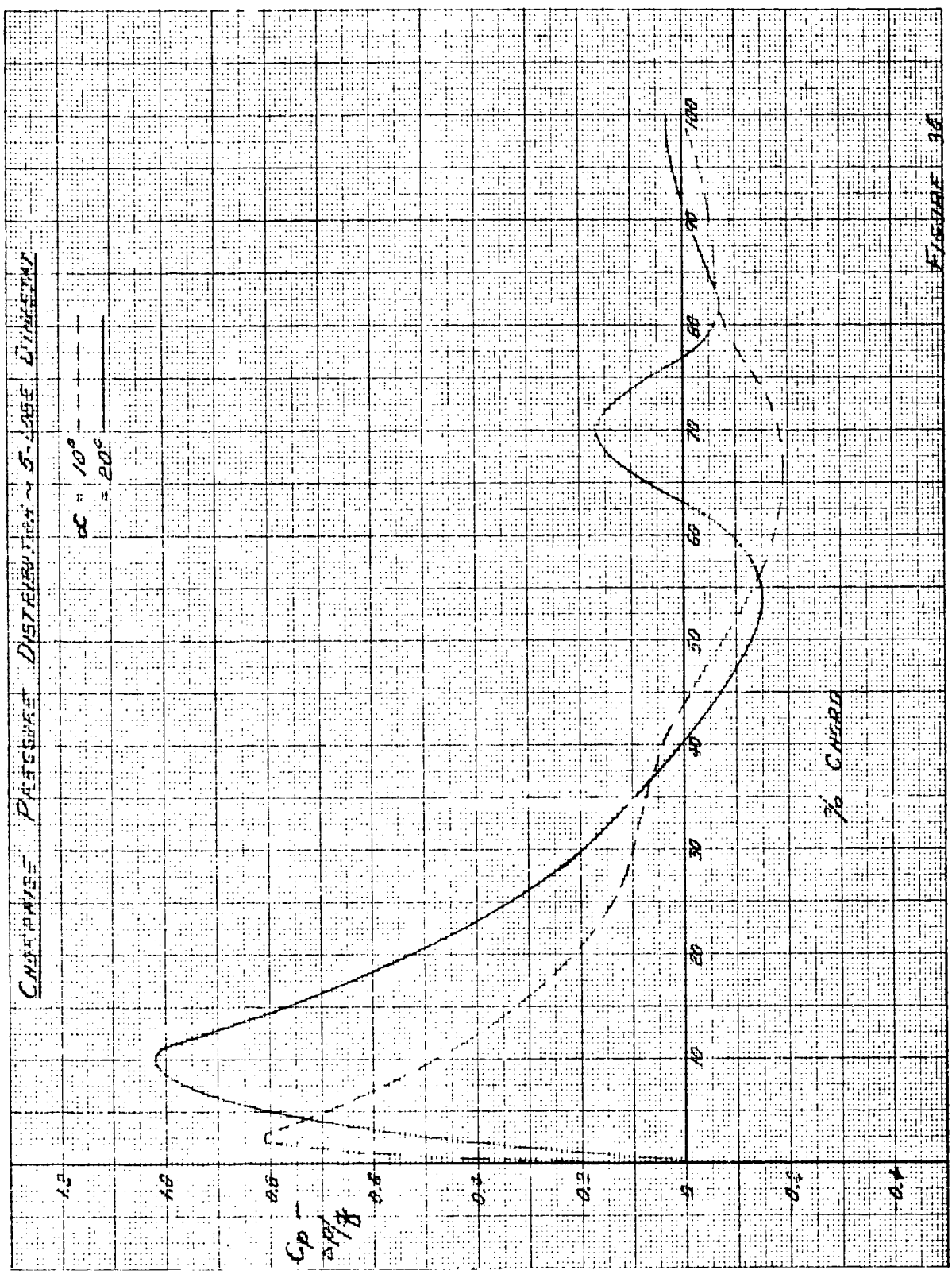


FIGURE 3A

TABLE V-9

AERODYNAMIC MOMENTS - 5-LOBE (AIR LOADS ONLY)

$$\alpha = 20^\circ, L_s/W_o = .60$$

Sta.	$\frac{b}{L}$	Ave. C_p	$C_p \left(\frac{b}{L}\right)$	$\frac{C_p b \Delta L}{L^2}$	$\frac{C_p q b \Delta L}{L^2} =$ $\frac{3.259}{.0892} \frac{C_p b \Delta L}{L^2}$	Arm to 0	100M
0	.315	0	0				
.1	.473	+1.03	+.487	+.0340	+1.241	.05	+ 6.21
.2	.496	+ .53	+.263	+.0375	+1.370	.15	20.55
.3	.520	+ .20	+.104	+.0184	+ .672	.25	16.80
.4	.520	+ .01	+.005	+.0054	+ .198	.35	6.93
.5	.500	- .13	-.065	-.0030	- .109	.45	- 4.90
.6	.461	- .11	-.051	-.0058	- .212	.55	-11.66
.7	.420	+ .17	+.071	+.0010	+ .037	.65	+ 2.40
.8	.381	- .06	-.023	+.0024	+ .088	.75	+ 6.60
.9	.343	- .01	-.003	-.0013	- .047	.85	- 3.99
1.0	.315	+ .03	+.009	+.0006	+ .022	.95	+ 2.09
				+.0892	3.260		41.03

TABLE V-10

CALCULATION OF NON-DIMENSIONAL SHEARS AND BENDING MOMENTS

$$\alpha = 20^\circ, \frac{L_s}{W_o} = .60, n_z = 1.7 \text{ g's}$$

Sta.	Buoyant Lift = $2.91 \frac{\Delta V}{V}$ (↑)	$\frac{1.7 \Delta m}{V}$ (↓)	(Net) (↓)	Arm to 0	106M	$\frac{2.047 C_p b \Delta L}{.0892 L^2}$ Aero Loads (+↑)	Total Loads	Shear Parameter	Moment Parameter
0	.168	.425	.257	.05	1.28	+.781	+.524		
.1	.386	.712	.326	.15	4.89	+.860	+.534	.524	.524
.2	.473	.986	.513	.25	12.83	+.423	-.090	1.058	15.82
.3	.475	1.208	.733	.35	25.65	+.124	-.609	.968	25.50
.4	.466	.916	.450	.45	20.25	-.069	-.519	.359	29.09
.5	.393	.692	.299	.55	16.45	-.133	-.432	-.160	27.49
.6	.274	.539	.265	.65	17.23	+.023	-.242	-.592	21.57
.7	.192	.287	.095	.75	7.12	+.055	-.040	-.834	13.23
.8	.081	.218	.137	.85	11.64	+.576	+.439	-.874	.449
.9	.001	.185	.184	.95	17.48	+.620	+.436	-.435	+.14
1.0	2.909	3.377	3.259		134.82	3.260		+.001	

$$90 F_t / mV - 134.82 + (3.259 - F_t / mV) 12.60 = 0$$

$$77.40 F_t / mV = 134.82 - 41.0 = 93.8 \quad F_t / mV = 1.212 \quad 3.259 - 1.212 = 2.047$$

TABLE V-11

NON-DIMENSIONAL SHEARS AND BENDING MOMENTS

$$L_s/W_o = .60, \alpha = 10^\circ$$

Assume 1.7 g's, best mass distribution

Sta.	Buoyant Lift $2.91 \frac{\Delta V}{V}$ (↑)	$1.7 \frac{\Delta m}{mV}$ (↓)	(Net) (↓)	Arm to 100M	Aero Loads (↑)	Total Loads	Shear Parameter	Moment Parameter
0	.168	.425	.257	.05	1.28	1.079	+.822	0
.1	.386	.712	.326	.15	4.89	.778	+.452	8.22
.2	.473	.986	.513	.25	12.83	.369	-.144	20.96
.3	.475	1.208	.733	.35	25.65	.143	-.590	32.26
.4	.466	.916	.450	.45	20.25	-.061	-.511	37.66
.5	.393	.692	.299	.55	16.45	-.252	-.551	37.95
.6	.274	.539	.265	.65	17.23	-.317	-.582	32.73
.7	.192	.287	.095	.75	7.12	-.239	-.334	21.69
.8	.081	.218	.137	.85	11.64	+.849	+.712	7.31
.9	.001	.185	.184	.95	17.48	+.910	+.726	+.05
1.0	2.909	6.168	3.259		134.82	3.259		

$$F_t/mV (90) - 134.82 - (3.259 - F_t/mV) 28.0 = 0$$

$$118.0 F_t/mV = 134.82 + 91.25 = 226.07$$

$$F_t/mV = 1.916$$

$$3.259 - 1.916 = 1.343$$

TABLE V-12
AERODYNAMIC LOADS

$$\alpha = 10^\circ, \frac{L_s}{W_o} = .60$$

Sta.	$\frac{b}{L}$	Ave C_p	$C_p \left(\frac{b}{L}\right)$	$\frac{C_p b \Delta L}{L^2}$	Arm to 0	100M (Aero)	For $\frac{L_s}{W_o} = .60$ $\frac{1.343}{.0309} \frac{C_p b \Delta L}{L^2}$	Tail Load	Total Aero Load
0	.315								
	(.344)	(.63)	(.248)	.0248	.05	.1240	1.079	...	+1.079
.1	.473	.49	.232	.0179	.15	.2685	.778	...	+ .778
.2	.496	.255	.126	.0085	.25	.2125	.369	...	+ .369
.3	.520	.085	.044	.0033	.35	.1155	.143	...	+ .143
.4	.520	.04	.021	-.0014	.45	-.0630	.061	...	- .061
.5	.500	-.10	-.050	-.0058	.55	-.3190	-.252	...	- .252
.6	.461	-.14	-.065	-.0073	.65	-.4745	-.317	...	- .317
.7	.420	-.19	-.080	-.0055	.75	-.4125	-.239	...	- .239
.8	.381	-.08	-.030	-.0025	.85	-.2125	-.109	+.958	+ .849
.9	.343	-.06	-.021	-.0011	.95	-.1045	-.048	+.958	+ .910
1.0	.315	0	0	.0309 ↑		-.8655	1.343	1.916	3.259

TABLE V-13

MASS DISTRIBUTION ($L_s/W_o = .80$)

Sta.	$\frac{\Delta V}{V}$	% W	$\frac{\% W_o}{\frac{\Delta V(100)}{\% W_o}} = .01037 \% W_o$	$\frac{.170 \Delta V}{V}$	$\frac{\Delta m}{\rho V}$	Add'l Mass Incl. Tail	Total $\frac{\Delta m}{\rho V}$
0	.0060	10.4	.1078	.0098	.1176	.113	.231
.1	.1053	11.4	.1182	.0226	.1408	.260	.401
.2	.1602	16.2	.1680	.0276	.1956	.319	.515
.3	.1650	21.8	.2261	.0278	.2539	.320	.574
.4	.1616	14.8	.1535	.0272	.1807	.313	.494
.5	.1585	8.7	.0902	.0230	.1132	.265	.378
.6	.1118	8.4	.0871	.0160	.1031	.184	.287
.7	.0765	2.9	.0301	.0112	.0413	.129	.170
.8	.0555	3.3	.0342	.0048	.0390	.089	.128
.9	.0006	2.1	.0218	.0001	.0219	.087	.109
1.0	0				1.2071	2.079	3.287

For $W_o/L_s = .80$, $k_4 = 1.207$, $k_{3b} = 1.96$, $k_{3t} = .12$

TABLE V-14
MASS DISTRIBUTION ($\frac{L_s}{W_o} = 1.0$)

Sta.	$\frac{\Delta V}{V}$	% W_o	$\frac{\% W_o}{\rho V(100)} =$ 0.0830% W	.170 $\frac{\Delta V}{V}$	$\frac{\Delta m}{\rho V}$	Add'l Mass Incl Tail	Total $\frac{\Delta m}{\rho V}$
0	.0577	12.3	.1021	.0098	.1119	.113	.225
.1	.1328	13.4	.1112	.0226	.1338	.260	.394
.2	.1626	14.9	.1237	.0276	.1513	.319	.470
.3	.1633	19.8	.1643	.0278	.1921	.320	.512
.4	.1600	12.2	.1013	.0272	.1285	.313	.441
.5	.1352	8.7	.0722	.0230	.0952	.265	.360
.6	.0941	8.5	.0706	.0160	.0866	.184	.271
.7	.0660	3.5	.0290	.0112	.0402	.129	.169
.8	.0280	4.1	.0340	.0048	.0388	.089	.128
.9	.0003	2.6	.0216	.0001	.0217	.087	.109
1.0			.8300		1.0001	2.079	3.079

REF: ENGINEERING PROCEDURE S.017

TABLE V-15

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .80, \alpha = 10^\circ, n_z = 1.7 \text{ g's}$$

Sta.	Buoyant Lift = $2.91 \frac{\Delta V}{V}$ ↑	$1.7 \frac{\Delta m}{\Delta \rho V}$ ↓	(Net) (↓)	Arm to 0	100M	Aero Loads	Total Loads	Shear Parameter	Moment Parameter
0	.168	.392	.224	.05	1.12	.862			
							.638		
.1								.638	
	.386	.682	.296	.15	4.44	.622	.326		6.38
.2								.964	
	.473	.875	.402	.25	10.05	.296	-.106		16.02
.3								.858	
	.475	.975	.500	.35	17.50	.115	-.385		24.60
.4								.473	
	.466	.839	.373	.45	16.79	-.049	-.422		29.33
.5								+.051	
	.393	.642	.249	.55	13.69	-.201	-.450		29.84
.6								-.399	
	.274	.488	.214	.65	13.91	-.253	-.467		25.85
.7								-.866	
	.192	.289	.097	.75	7.26	-.191	-.288		17.19
.8								-1.154	
	.081	.218	.137	.85	11.65	+.713	+.576		5.65
.9								-.578	
	.001	.185	.184	.95	17.48	+.762	+.578		-.13
1.0								0	
	2.909	5.585	2.676		113.88				

$$F_t/\rho V(90) - 113.88 - (2.676 - F_t/\rho V) 28.0 = 0 \quad F_t/\rho V = 1.600$$

$$118.0 F_t/\rho V = 113.88 + 74.93 = 188.81$$

$$2.676 - 1.600 = 1.076$$

TABLE V-16

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = 1.0, \alpha = 10^0, n_z = 1.7 \text{ g's}$$

Sta.	Buoyant Lift = $2.91 \frac{\Delta \Psi}{V}$ (A)	$1.7 \frac{\Delta m}{\Delta \Psi}$ (V)	(Net) (V)	Arm to 0	100M	Aero Loads A	Total Loads	Shear Parameter	Moment Parameter
0	.168	.382	.214	.05	1.07	.739	+.525		
.1	.386	.670	.284	.15	4.26	.534	+.250	.525	5.25
.2	.473	.799	.326	.25	8.15	.254	-.072	.775	13.00
.3	.475	.871	.396	.35	13.85	.098	-.298	.703	20.03
.4	.466	.750	.284	.45	12.76	-.042	-.326	.405	24.08
.5	.393	.612	.219	.55	12.03	-.173	-.392	.079	25.87
.6	.274	.460	.186	.65	12.08	-.217	-.403	-.313	21.74
.7	.192	.287	.095	.75	7.12	-.164	-.259	-.716	14.58
.8	.081	.218	.137	.85	11.64	+.627	+.490	-.975	4.83
.9	.001	.185	.184	.95	17.48	+.669	+.485	..485	-.02
1.0	2.909	5.234	2.325		100.44	2.327			

$$F_t/\rho V(90) - 100.44 - (2.325 - F_t/\rho V) 28.0 = 0 \quad F_t/\rho V = 1.403$$

$$118.0 F_t/\rho V = 100.44 + 65.10 = 165.54$$

$$2.325 - 1.403 = .922$$

TABLE V-17

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = 1.0, \alpha = 20^\circ, n_z = 1.7 \text{ g's}$$

Sta.	Buoyant Lift = $2.91 \frac{\Delta m}{V}$ ↑	$1.7 \frac{\Delta m}{\rho V}$ ↓	↓ (Net)	Arm to 0	100M	↑ Aero Loads	Total Loads	Shear Parameter	Moment Parameter
0	.168		.214		1.07	+.536	+.322		
.1	.386		.284		4.26	+.591	+.307	+.322	+3.22
.2	.473		.326		8.15	+.290	-.036	+.629	9.51
.3	.475		.396		13.85	+.085	-.311	+.593	15.44
.4	.466		.284		12.76	-.047	-.331	+.282	18.26
.5	.393		.219		12.03	-.091	-.310	-.049	17.77
.6	.274		.186		12.08	+.016	-.170	-.359	14.18
.7	.192		.095		7.12	+.038	-.057	-.529	8.89
.8	.081		.137		11.64	+.439	+.302	-.586	3.03
.9	.001		.184		17.48	+.468	+.284	-.284	+.19
1.0								0	
			2.325		100.44				

$$F_t/\rho V(90) - 100.44 + (2.325 - F_t/\rho V) 12.59 = 0$$

$$F_t/\rho V = .919$$

$$77.41 F_t/\rho V = 100.44 - 29.27 = 71.17$$

$$2.325 - .919 = 1.406$$

TABLE V-18

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .80, \alpha = 20^\circ, z = 1.7 \text{ g's}$$

Sta.	Buoyant Lift = $2.91 \frac{\Delta \Psi}{\Psi}$	$1.7 \frac{\Delta m}{\rho \Psi}$	(Net)	Arm to 0	100 M	$\frac{1.641}{.0892} \frac{C_p b \Delta L}{L^2}$	Total Loads	Shear Para meter	Moment Para meter
0			.224		1.12	.626	.402		
.1			.296		4.44	.690	.394	.402	4.02
.2			.402		10.05	.339	-.063	.796	11.98
.3			.500		17.50	+.099	-.401	.733	19.31
.4			.373		16.79	-.055	-.428	.332	22.63
.5			.249		13.69	-.107	-.356	-.096	21.67
.6			.214		13.91	+.018	-.196	-.452	17.15
.7			.097		6.83	+.044	-.053	-.648	10.67
.8			.137		11.65	+.494	+.357	-.701	3.66
.9			.184		17.48	+.528	-.344	-.344	.22
1.0									
			2.676		113.88	2.676			

$$F_t/\rho \Psi(90) - 113.88 - (2.676 - F_t/\rho \Psi) 12.59 = 0$$

$$F_t/\rho \Psi = 1.035$$

$$77.41 F_t/\rho \Psi = 113.88 - 33.69 = 80.19$$

$$2.676 - 1.030 = 1.641$$

TABLE V-19

NON-DIMENSIONAL SHEARS AND MOMENTS

$L_s/W_o = 1.0$, Static Condition ($\alpha = 0$, $n_z = 1.0$ g)

Sta.	Buoyant Lift = .830 $\frac{\Delta V}{V}$	% $W_o =$ $\frac{100 \Delta V}{.830 (\% W)}$	Net Force	Shear Para meter	Moment Para meter	Arm to 0	Net 100M _o	Lift Moment	Weight Moment
0	↑	↓							
	.0479	.1021	-.0542			.05	-0.271	.24	.51
.1				-.0542					
	.1102	.1112	-.0010		-0.542	.15	-0.015	1.65	1.67
.2				-.0552					
	.1350	.1237	+.0113		-1.094	.25	+0.282	3.37	3.09
.3				-.0439					
	.1355	.1643	-.0288		-1.533	.35	-1.007	4.75	5.75
.4				-.0727					
	.1328	.1013	+.0315		-2.260	.45	+1.417	5.97	4.56
.5				-.0412					
	.1122	.0722	+.0400		-2.672	.55	+2.200	6.17	3.97
.6				-.0012					
	.0781	.0706	+.0075		-2.684	.65	+0.487	5.07	4.59
.7				+.0063					
	.0548	.0290	+.0258		-2.621	.75	+1.935	4.11	2.17
.8				+.0321					
	.0232	.0340	-.0108		-2.300	.85	-.918	1.97	2.89
.9				+.0213					
	.0003	.0216	-.0213		-2.087	.95	-2.023	.03	2.05
1.0				0					
	.8300	.8300					+2.087	33.33	31.25

TABLE V-20

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .80, \alpha = 10^\circ, 1.0 \text{ g's}$$

Sta.	Buoyant Lift = $.830 \frac{\Delta \Psi}{\Psi}$ ↑	$\frac{\% W_o}{100} =$ $.1037 \frac{\Delta \Psi}{\Psi}$ ↓	(Net)	Arm to 0	100 M	Aero Loads	Total Loads	Shear Para meter	Moment Para meter
0	.0479	+ .1078	-.0599	.05	-.300	.0870	.0271		
.1	.1102	.1182	-.0080	.15	-.120	.0627	.0547	.0271	.271
.2	.1350	.1680	-.0330	.25	-.825	.0298	-.0032	.0818	1.089
.3	.1355	.2261	-.0906	.35	-3.171	.0116	-.0790	.0786	1.875
.4	.1328	.1535	-.0207	.45	-.931	-.0049	-.0256	-.0004	1.871
.5	.1122	.0902	+.0220	.55	+1.210	-.0203	+.0017	-.0260	1.611
.6	.0781	.0871	-.0090	.65	-.585	-.0256	-.0346	-.0243	1.368
.7	.0548	.0301	+.0247	.75	+1.854	-.0193	+.0054	-.0589	.779
.8	.0232	.0342	-.0110	.85	-.934	+.0406	+.0296	-.0535	.244
.9	.0003	.0218	-.0215	.95	-2.043	+.0454	+.0239	-.0239	+.005
1.0	.8300	1.0370	.2070		-5.845	+.2070			

$$F_t/\rho \Psi(90) - 5.845 - (.2070 - F_t/\rho \Psi) 28.0 = 0$$

$$F_t/\rho \Psi = .0987$$

$$118.0 F_t/\rho \Psi = 5.845 + 5.796 = 11.641$$

$$.2070 - .0987 = .1083$$

TABLE V-21

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .80, \alpha = 20^\circ, 1.0 \text{ g's}$$

Sta.	Buoyant Lift = .830	$\frac{\% W_o}{100 \Psi}$.01037 % W_o	Net	Arm to 0	100M	Aero Loads	Total Loads	Shear Parameter	Moment Parameter
0			-.0599			+.0630	+.0031		
.1			-.0080			+.0694	+.0614	+.0031	+0.031
.2			-.0330			+.0341	+.0011	+.0645	+0.676
.3			-.0906			+.0100	-.0806	+.0656	+1.332
.4			-.0207			-.0056	-.0263	-.0150	+1.182
.5			+.0220			-.1007	+.0113	-.0413	+0.769
.6			-.0090			+.0019	-.0071	-.0300	+0.469
.7			+.0247			+.0044	+.0291	-.0371	+0.098
.8			-.0110			+.0185	+.0075	-.0080	+0.018
.9			-.0215			+.0220	+.0005	-.0005	+0.013
1.0								0	

5.845

$$F_t/\Psi(90) - 5.845 + (.2070 - F_t/\Psi) 12.59$$

$$F_t/\Psi = .04184$$

$$77.41 F_t/\Psi = 5.845 - 2.606 = 3.239$$

$$.2070 - .0418 = .1652$$

TABLE V-22

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .60, \alpha = 10^\circ, 1.0 \text{ g's}$$

Sta.	Buoyant Lift = 830	$\frac{\% W_o}{100 \rho V} =$.0138 (% W_o)	Net	Arm to 0	100M	Aero Loads	Total Loads	Shear Parameter	Moment Parameter
0	.0479	.1268	.0789	.05	0.39	.2128	+.1339		
.1	.1102	.1365	.0263	.15	0.40	.1536	+.1273	.1339	1.339
.2	.1350	.2330	.0980	.25	2.45	.0729	-.0251	.2612	3.951
.3	.1355	.3630	.2275	.35	7.96	+.0283	-.1992	+.2361	6.312
.4	.1328	.1986	.0658	.45	2.96	-.0120	-.0778	+.0369	6.681
.5	.1122	.1186	.0064	.55	0.35	-.0498	-.0562	-.0409	6.272
.6	.0781	.1173	+.0392	.65	+2.55	-.0626	-.1018	-.0971	5.301
.7	.0548	.0290	-.0258	.75	-1.93	-.0472	-.0214	-.1989	3.312
.8	.0232	.0344	+.0112	.85	+0.95	+.1206	+.1094	-.2203	1.109
.9	.0003	.0221	+.0218	.95	+2.07	+.1327	+.1109	-.1109	0
1.0	.8300	1.3793	+.5493		18.15			0	

$$F_t/\rho V (90) - 18.15 - (.5493 - F_t/\rho V) 28.0$$

$$F_t/\rho V = .2842$$

$$118.0 F_t/\rho V = 18.15 + 15.38 = 33.53$$

$$.5493 - .2842 = .2651$$

TABLE V-23

NON-DIMENSIONAL SHEARS AND MOMENTS

$$L_s/W_o = .60, \alpha = 20^\circ, 1.0 \text{ g's}$$

Sta.	Buoyant Lift = .830	$\frac{\% W_o}{100 \mu V} =$.0138 (% W_o)	Net	Arm to 0	100 M	Aero Loads	Total Loads	Shear Parameter	Moment Parameter
0	.0479	.1268	.0789	.05	.39	.1541	+.0752		
.1	.1102	.1365	.0263	.15	.40	.1699	.1436	+.0752	+0.752
.2	.1350	.2330	.0980	.25	2.45	.0834	-.0146	+.2188	2.940
.3	.1355	.3630	.2275	.35	7.96	.0245	-.2030	+.2042	4.982
.4	.1328	.1986	.0658	.45	2.96	-.0136	-.0794	+.0012	4.994
.5	.1122	.1186	.0064	.55	.35	-.0263	-.0327	-.0782	4.212
.6	.0781	.1173	+.0392	.65	+2.55	+.0045	-.0347	-.1109	3.103
.7	.0548	.0290	-.0258	.75	-1.93	+.0109	+.0367	-.1456	1.647
.8	.0232	.0344	+.0112	.85	+0.95	+.0666	+.0554	-.1089	.558
.9	.0003	.0221	+.0218	.95	+2.07	+.0753	+.0535	-.0535	.23
1.0									
			.5493		18.15				

$$F_t/\mu V(90) = 18.15 + (.5493 - F_t/\mu V) 12.59$$

$$F_t/\mu V = .1451$$

$$77.41 F_t/\mu V = 18.15 - 6.92 = 11.23$$

$$.5493 - .1451 = .4042$$

When the airship is subjected to $n_z = 1.0$ g's only, this means the airship is not being accelerated; therefore the additional mass does not enter into the calculations. The buoyant lift in Tables V-19 to V-23 therefore does not include buoyancy of an additional mass. In Table V-19, ($L_s/W_o = 1.0$, $\alpha = 0$, $n_z = 1.0$) there is no air load to be considered. The remaining tables (V-20 to V-23) are obtained similarly to the previous series. Note that the combinations of $L_s/W_o \neq 1.0$ with $\alpha = 0$, and of $L_s/W_o = 1.0$ with either $\alpha > 0$ and $n_z = 1.0$ or $\alpha = 0$ and $n_z > 1.0$, are all physically incompatible.

f. Resisting Moments

In Reference 23, page 21, expressions for the first-wrinkling moment of a 4-cell airship envelope are given based on the assumption that the longitudinal inflation stresses are distributed uniformly in proportion to cloth weight, which in turn is assumed proportional to the hoop and vertical web stresses. A more efficient design might have the internal webs able to take only vertical stress - no longitudinal stress.

Modifying the expressions of Reference 23 for a 5-cell configuration gives:

$$A_5 = \pi r_o^2 + 6r_i^2 \beta + 6r_i^2 \cos \beta \sin \beta \quad (12)$$

$$I'_5 = t_{ei} \left[\frac{\pi r_o^4}{r_i} + 6r_i^3 \left(\beta + \frac{\sin 2\beta}{2} \right) + 4r_i^3 \cos^3 \beta \sin \beta \right] \quad (13)$$

$$S'_5 = t_{ei} \left[2\pi r_o \cos \beta + 12 r_i \beta + 12 r_i \cos \beta \sin \beta \right] \quad (14)$$

$$C_5 = r_i = r_o \sec \beta \quad (15)$$

The maximum section is at Sta. 35 in the configuration being considered, but the maximum bending moment, when $\alpha = 20^\circ$, occurs at Sta. 45, where $r_i = .1125L$ (ref. Drg. 67QS977), and $r_o = .0980L$.

$$\cos \beta = \frac{r_o}{r_i} = .871$$

$$\beta = 29.4^\circ = .5135 \text{ rad}$$

$$\sin \beta = .491, \quad \sin 2\beta = .856$$

Also, since $L = 2.50 V^{1/3}$,

$$r_i = .281 V^{1/3}$$

$$r_o = .245 V^{1/3}$$

and (from equations 12 to 15)

$$A_5 = .188 V^{2/3} + .243 V^{2/3} + .202 V^{2/3} = .634 V^{2/3}$$

$$I'_5 = t_{ei} V \left[.0402 + .1250 + .0289 \right] = .1941 t_{ei} V$$

$$S'_5 = t_{ei} V^{1/3} \left[(1.340 + 1.732 + 1.444) \right] = 4.516 t_{ei} V^{1/3}$$

$$C_5 = .281 V^{1/3}$$

Then, if the wrinkling moment is

$$M_{wr} = \frac{p A I}{S c} \quad (16)$$

we have

$$p = \frac{M_{wr} S c}{A I} = \frac{M_{wr} (4.516) (.281) V^{2/3}}{(.634) (.1941) V^{5/3}}$$

$$p = 10.32 \frac{M}{V} = 2.58 V^{1/3} \left(\frac{M}{2.50 V^{2/3}} \right) \quad (17)$$

When $\alpha = 10^\circ$, the maximum moment may occur at Sta. .55, where $r_i = .0990 L$ (ref Drg. 67QS977), and $r_o = .0837 L$.

$$\cos \beta = \frac{r_o}{r_i} = \frac{.837}{.990} = .845$$

$$\beta = 32.3^\circ = .564 \text{ rad.}$$

$$\sin \beta = .535, \sin 2\beta = .904$$

Since $L = 2.50 V^{1/3}$

$$r_i = .247 V^{1/3}$$

$$r_o = .209 V^{1/3}$$

Equations 12 to 15 then give

$$A_5 = .137 V^{2/3} + .205 V^{2/3} + .205 V^{2/3} = .547 V^{2/3}$$

$$I'_5 = t_{ei} \Psi \left[.0242 + .0920 + .0195 \right] = .1357 t_{ei} \Psi$$

$$s'_5 = t_{ei} \Psi^{1/3} \left[1.108 + 1.672 + 1.342 \right] = 4.122 t_{ei} \Psi^{1/3}$$

$$C_5 = .247 \Psi^{1/3}$$

Then if p

$$= \frac{MSc}{AI} = \frac{M (4.122) (.247) t_{ei} \Psi^{2/3}}{(.547) (.1357) t_{ei} \Psi^{5/3}}$$

$$= 13.70 \frac{M}{\Psi} = 34.2 \Psi^{1/3} \left(\frac{M}{2.50 \Psi^{4/3}} \right) \quad (17A)$$

Sta. 35:

$$r_i = .1172L = .293 \Psi^{1/3}$$

$$r_o = 890 r_i = .261 \Psi^{1/3}$$

$$\cos \beta = .890, \sin \beta = .456$$

$$\beta = 27.2^\circ = .474 \text{ rad. } \sin 2\beta = .812$$

$$A_5 = .214 \Psi^{2/3} + .244 \Psi^{2/3} + .209 \Psi^{2/3} = .667 \Psi^{2/3}$$

$$I'_5 = 3 t_{ei} \Psi \left[.0496 + .1326 + .0324 \right] = .2142 t_{ei} \Psi$$

$$s'_5 = t_{ei} \Psi^{1/3} \left[1.456 + 1.666 + 1.427 \right] = 4.549 t_{ei} \Psi^{1/3}$$

$$C_5 = .293 \Psi^{1/3}$$

$$p = \frac{MSc}{AI} = \frac{M (4.549) (.293) t_{ei} \Psi^{2/3}}{(.667) (.2142) t_{ei} \Psi^{5/3}}$$

$$p = 9.33 \frac{M}{\Psi} = 23.35 \Psi^{1/3} \left(\frac{M}{2.50 \Psi^{4/3}} \right) \quad (17B)$$

Table V-24 gives a summary of the maximum bending moment parameters found in the calculations of Tables V-8 to V-23, the locations where the maximum moments occur, and the required inflation pressure for a non-rigid DYNASTAT to withstand these moments without wrinkling of the

envelope (from eqs. 17, 17A, or 17B). The critical pressure requirement is assumed to be determined by the maximum moment, which is conceivably - though improbably - slightly unconservative.

TABLE V-24

SUMMARY - MAXIMUM BENDING MOMENTS AND PRESSURE REQUIREMENTS

$\frac{L_s}{W_o}$	$n_z = 1.7 \text{ g's}$				$n_z = 1.0 \text{ g's}$		
	α , deg.	$\frac{100 M_{\max}}{2.50 \rho V^{4/3}}$	At Sta	$\frac{p}{\rho V^{1/3}}$	$\frac{100 M_{\max}}{2.50 \rho V^{4/3}}$	At Sta	$\frac{p}{\rho V^{1/3}}$
.60	20	29.09	.45	7.50	4.994	.45	1.29
.60	10	37.95	.55	13.00	6.681	.45	1.72
.60	0	X			X		
.80	20	22.63	.45	5.84	1.332	.35	.31
.80	10	29.84	.55	10.21	1.875	.35	.44
.80	0	X			X		
1.00	20	18.26	.45	4.71	X		
1.00	10	24.87	.55	8.50	X		
1.00	0	X			-1.5	.55	0.51

g. Fabric Tensions and Weight

Given the pressure, the maximum hoop tensions are readily found. If the internal webs are able to take longitudinal tension, the maximum longitudinal stress due to bending plus pressure at the wrinkling moment is equal to the hoop tension in a center cell outer wall. (If longitudinal pressure stresses are not uniformly distributed in proportion to the hoop and web tensions, this will not be true.) The maximum hoop tension, of course, always occurs at the maximum cross-section.

Internal cells, external walls:

$$f_{ie} = p r_i \quad (18)$$

or

$$f_{ie} = .281 p \Psi^{1/3} \quad (\text{at sta 45})$$

$$= .247 p \Psi^{1/3} \quad (\text{at sta 55})$$

Outer cells:

$$f_{co} = pr_o \quad (19)$$

$$f_{co} = .245pV^{1/3} \quad (\text{at sta 45})$$

$$= .209pV^{1/3} \quad (\text{at sta 55})$$

Internal webs - center two:

$$f_i = 2pr_i \sin \beta \quad (20)$$

$$= 2p (.281V^{1/3}) (.491) \quad (\text{sta 45})$$

or

$$= 2p (.247V^{1/3}) (.535) \quad (\text{sta 55})$$

$$f_i = .276V^{1/3}p \quad (\text{sta 45})$$

$$= .264V^{1/3}p \quad (\text{sta 55})$$

Internal webs - outer two:

$$f_{oi} = pr_i \sin \beta \quad (21)$$

$$= .138V^{1/3}p \quad (\text{sta 45})$$

$$= .132V^{1/3}p \quad (\text{sta 55})$$

At the maximum section (sta. 35) $r_i = .1172L = 293V^{1/3}$ and $r_o = .890r_i$,
so $\cos \beta = .890$, $\sin \beta = .456$ so:

$$f_{ie} = .293pV^{1/3}$$

$$f_{co} = .261pV^{1/3}$$

$$f_i = 2(.293pV^{1/3})(.456) = .268pV^{1/3}$$

$$f_{oi} = .134pV^{1/3}$$

(But $r_i \sin \beta$ is constant, so the apparent variation of f_i and f_{oi} is only inaccuracy.)

Figure 35A shows the 5-lobe DYNASTAT cross-section and Table V-25 gives the fabric tension parameters for each of the conditions of Table V-24.

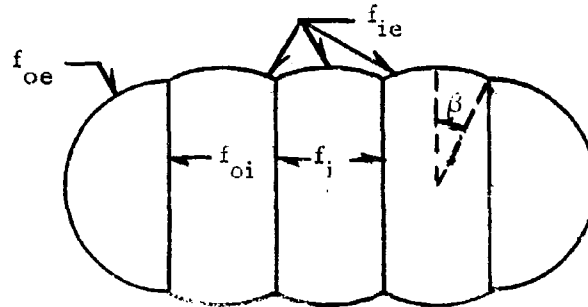


Figure 35A - 5-Lobe DYNASTAT Cross-Section

NOTE: $f_i = 2f_{oi}$

TABLE V-25

NON-DIMENSIONAL FABRIC TENSIONS

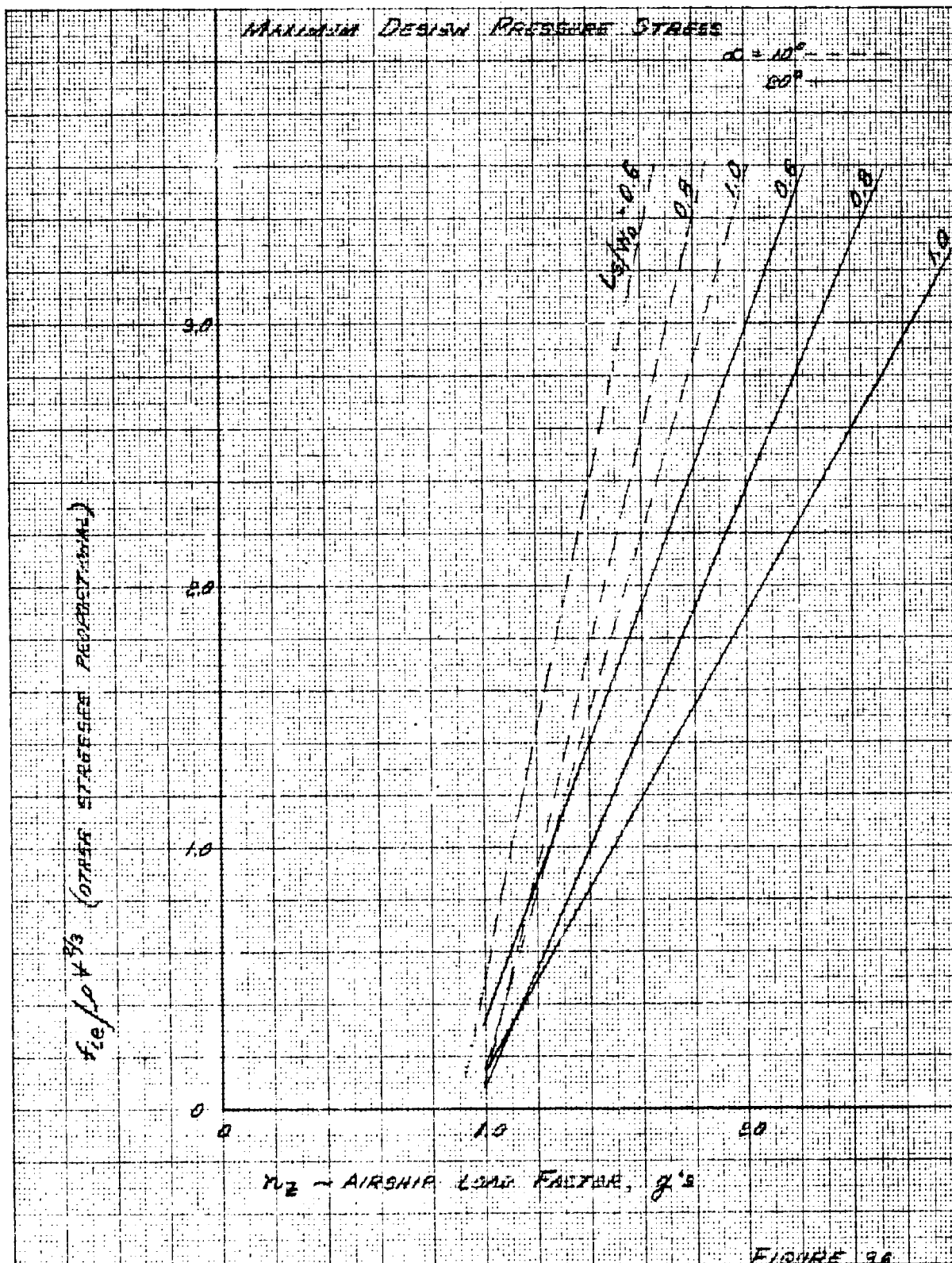
$\frac{L_s}{W_o}$	∞ deg.	For 1.7 g's				For 1.0 g's			
		$\frac{p}{\sqrt{1/3}}$	$\frac{f_{ie}}{\sqrt{2/3}}$	$\frac{f_{oe}}{\sqrt{2/3}}$	$\frac{f_{oi}}{\sqrt{2/3}}$	$\frac{p}{\sqrt{1/3}}$	$\frac{f_{ie}}{\sqrt{2/3}}$	$\frac{f_{oe}}{\sqrt{2/3}}$	$\frac{f_{oi}}{\sqrt{2/3}}$
.60	20	7.50	2.20	1.96	1.01	1.29	.378	.336	.173
.60	10	13.00	3.81	3.39	1.74	1.74	.504	.448	.230
.60	0	...	...	...	...	...	...	...	...
.80	20	5.84	1.71	1.52	0.79	.31	.091	.081	.042
.80	10	10.21	2.99	2.67	1.37	.44	.129	.115	.059
.80	0	...	...	...	...	...	...	...	...
1.00	20	4.71	1.38	1.23	0.63	...	...	...	...
1.00	10	8.50	2.49	2.22	1.14	...	...	...	...
1.00	0	...	...	...	...	.51	.149	.133	.068

Since the moments are proportional to n_z for given values of L_s/W_o and ∞ , the straight-line graphs of Figure 36 can be drawn from the data of Table V-25. (Slopes of the $L_s/W_o = 1.00$ lines are drawn to the static condition of $n_z = 1.0$, which is incorrect but probably not far wrong,

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judging from the other curves.) By interpolation, values of the stress parameter $f_{ie}/\rho V^{2/3}$ can be obtained for any set of conditions L_s/W_o , α , and n_z .

Figure 37 is provided for convenience in converting initial angles of attack, α_o , to α in a 30 fps vertical upward gust. To find α_o , Figure 34 must be entered with the airship volume, L_s/W_o , and airship velocity. With the same given factors, Figure 32 or 33 can be entered to find n_z . With α , L_s/W_o , and n_z , Figure 36 can be entered to obtain $f_{ie}/\rho V^{2/3}$, from which f_{ie} is readily obtained since V is given and ρ can be specified according to flight altitude. Knowing the envelope material weight-to-strength ratio, the structural weight of the envelope can be estimated for any size of 5-lobe DYNASTAT designed to the specified conditions.

Because all of the work to this point was based on the assumption $C_{L_{\alpha eff}} = 2C_{L_{\alpha}}$, a correction is necessary if $C_{L_{\alpha eff}} = C_{L_{\alpha}}$, as discussed in the introduction to the DYNASTAT analysis. In that case, if n_{zo} is the value of n_z for $C_{L_{\alpha eff}} = 2C_{L_{\alpha}}$,

$$n_z = \frac{n_{zo} + 1}{2} \quad (22)$$

Figures 38 and 39 give correction factors which can be applied to moments, pressures, stresses and weights for this case. They are obtained by reducing n_z according to equation (22), and ratioing the resulting values obtained from Figure 36 to the original values of the fabric tension parameters. Weights used in the performance section of this report were based on these corrections.

2. FLEXURAL STRENGTH OF THIN-WALLED PRESSURIZED CYLINDERS IN APPLICATION TO METAL-CLAD AIRSHIPS

a. Introduction

If length, radius, and material characteristics of the cylinder are given, the buckling and the collapse moment are functions of the wall thickness, t , and the pressure, p (Reference 29). As the pressure is increased hoop tension

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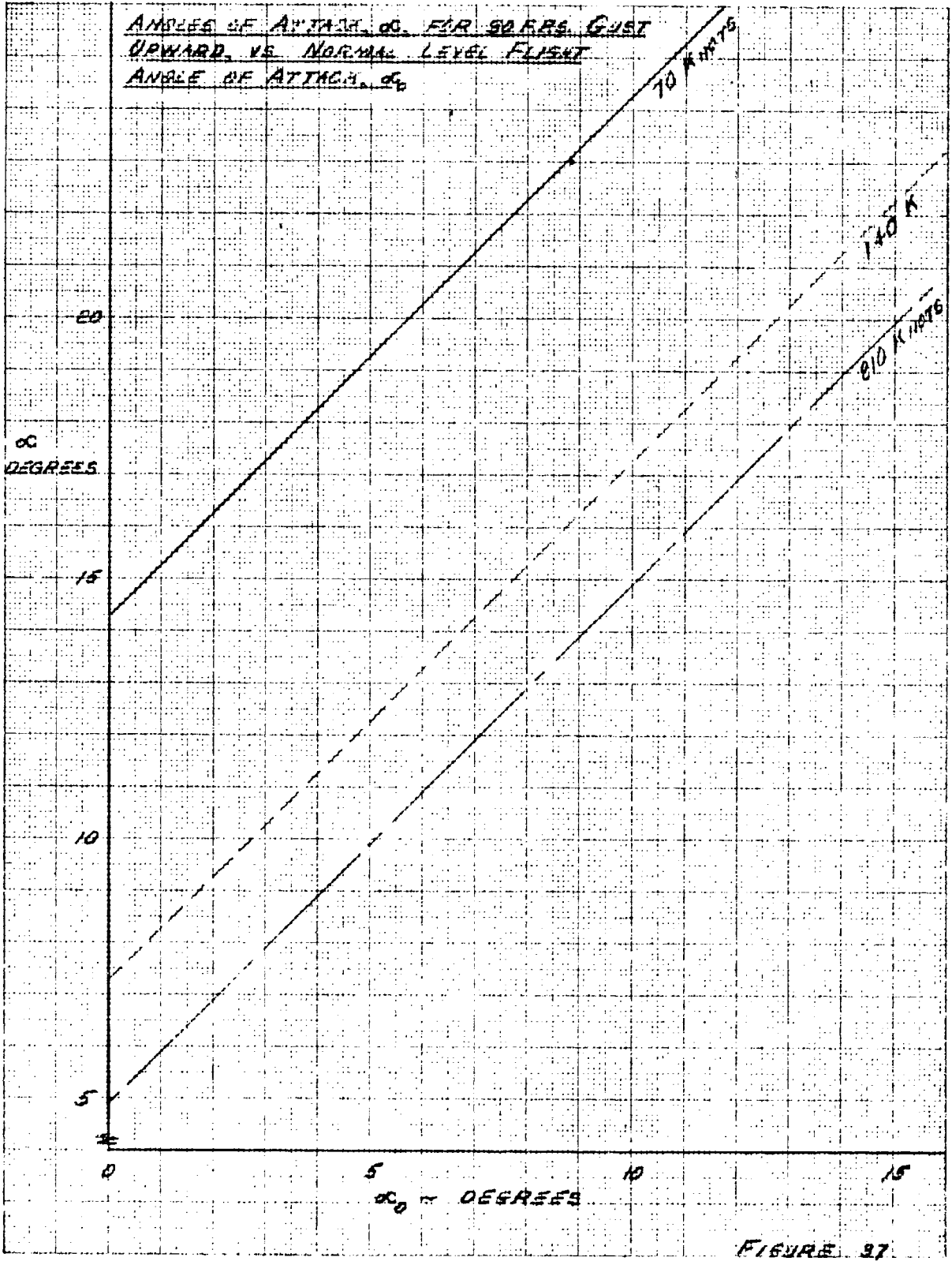


FIGURE 37

JR 220 (7-63)
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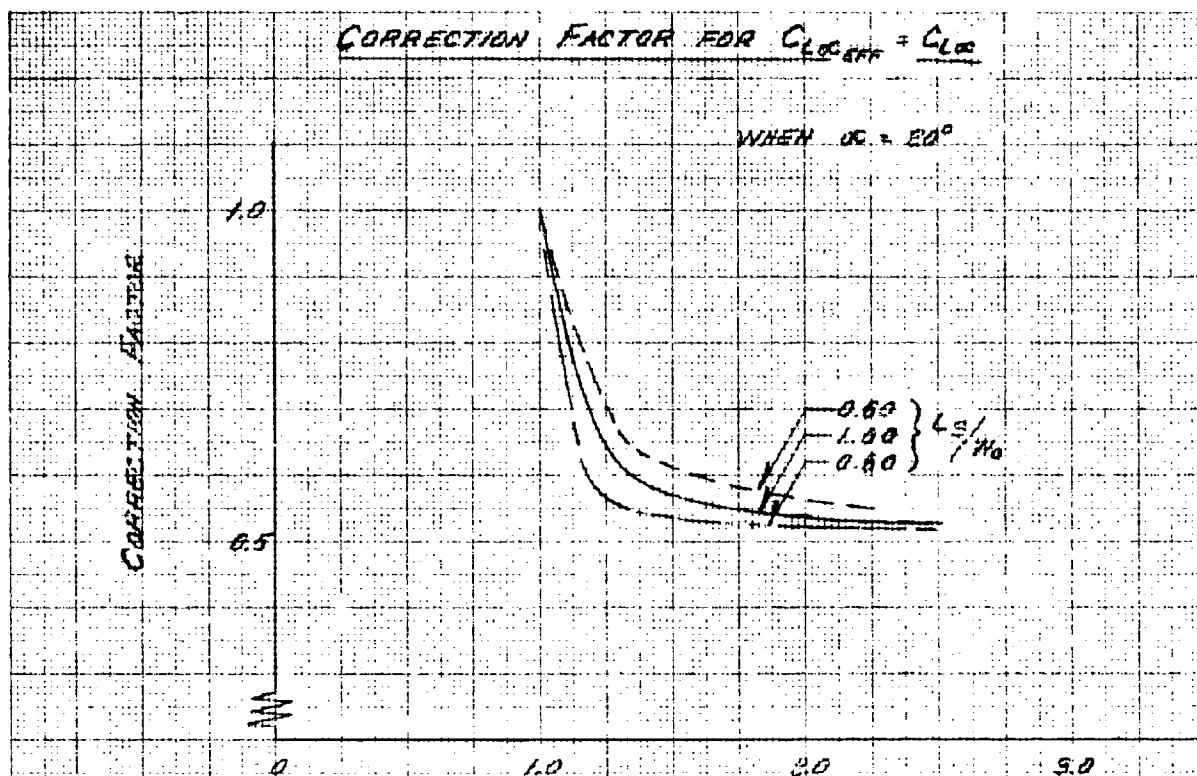


FIGURE 38

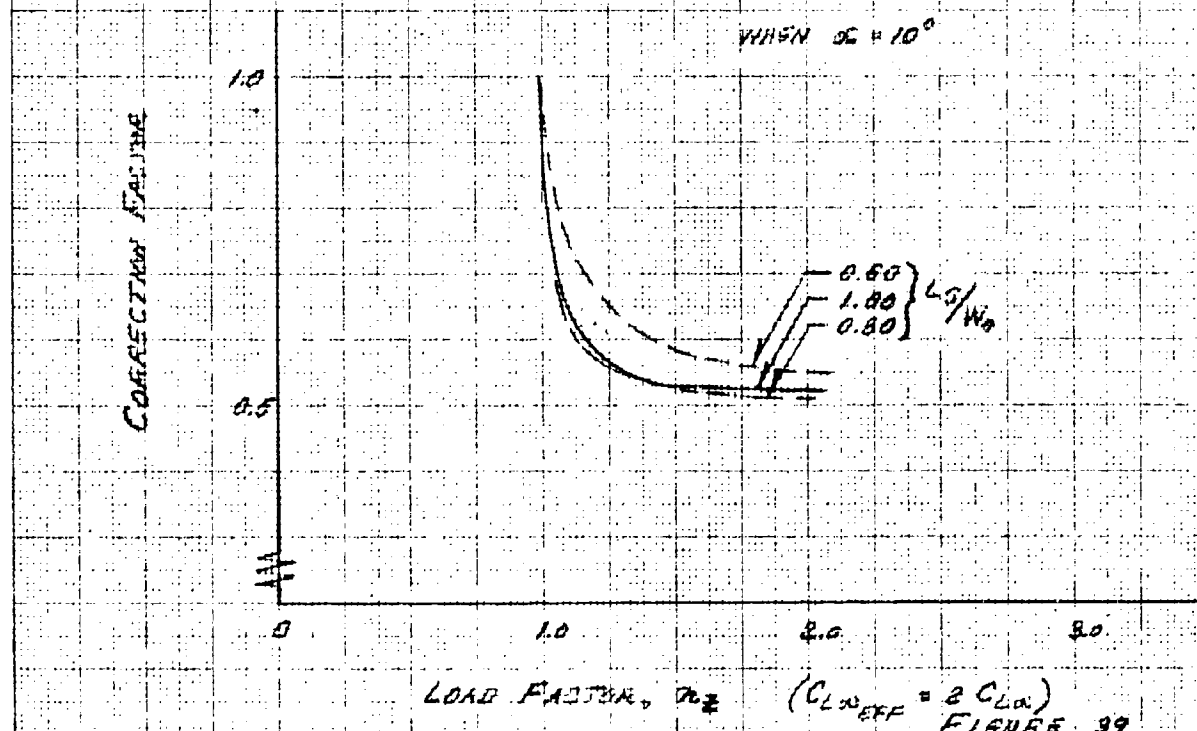


FIGURE 39

and longitudinal tensile stresses also increase, the former in proportion to the pressure, the latter due to the combined effect of pressure and increasing buckling (or collapse) moment.

It is apparent, then, that for a given limit bending moment, M , the optimum combination of the parameters t and p is obtained if the following conditions are met:

1. The buckling moment is $M_B = n_B \cdot M$, where n_B is the desired or specified safety factor in buckling.
2. The hoop tension is

$$\frac{pr}{t} = \frac{F_t^u}{n_H}$$

It is not necessary, in the case on hand, to impose an additional condition for the maximum longitudinal tensile stresses due to pressure and buckling moment, since those stresses just reach or very slightly exceed the limit hoop stresses.

If, however, the condition (1) defined above were modified and based on the collapse moment, M_c , rather than on the buckling moment, and if it were stipulated that tensile rupture ought not to occur before collapse, then the condition

$$\sigma_{x \max}(C) \leq \frac{F_{tu}}{n_L}$$

might in some cases overrule the condition (2) given above, depending on the effective section modulus that is left in the partially wrinkled cylinder wall just prior to collapse and also on the safety factors involved.

For the purpose of a parametric study it suffices to base the analysis on the conditions (1) and (2).

b. Analysis

The buckling moment of a pressurized cylinder is

$$M_B = M_p = 0 + 0.5 p \pi r^3 \quad (101)$$

(Reference 29, p. 20).

Herein:

$$M_p = 0 = \frac{\sigma_{xB_0} I}{c} = \sigma_x B_0 \pi r^2 t \quad (102)$$

with σ_{xB_0} , the buckling stress at zero pressure, being given by

$$\sigma_{xB_0} = \frac{\gamma E}{\sqrt{3(1 - \mu^2)}} \cdot \frac{t}{r} = 0.6 \gamma E \frac{t}{r} \quad (103)$$

where

$$\gamma = 1 - 0.731 (1 - e^{-\phi}) \quad (104)$$

and

$$\phi = \frac{1}{16} \sqrt{\frac{r}{t}} \quad (105)$$

(Reference 29).

Within the range of interest, ϕ is so large a number that γ becomes a constant:

$$\gamma = 0.269 \text{ (for } \frac{r}{t} \geq 15000) \quad (106)$$

From equations 101 through 103:

$$M_B = 0.6 \gamma E t^2 \pi r + 0.5 p \pi r^3 \quad (107)$$

or, with

$$M_B = n_B \cdot M \quad (108)$$

$$n_B \cdot M = 0.6 \gamma E t^2 \pi r + 0.5 p \pi r^3 \quad (109)$$

The limit hoop tension is:

$$\frac{pr}{t} = \sigma \frac{F_{tu}}{n_H} \quad (110)$$

hence the limit pressure

$$p = \sigma \frac{t}{r} \frac{F_{tu}}{n_H} \quad (111)$$

Substitute (111) into (109) for:

$$t^2 + \frac{5}{6} \frac{r \sigma F_{tu}}{n_H \gamma E} \cdot t = \frac{5}{3} \frac{n_B M}{\gamma E \pi r} \quad (112)$$

or, with the abbreviations:

$$a = \frac{5}{6} \frac{r_0^2 F_{tu}}{n_H \gamma E} \quad (113)$$

$$b = \frac{5}{3} \frac{n_B M}{\gamma E \pi r} \quad (114)$$

$$t^2 + at = b \quad (115)$$

which yields the solution

$$t = \sqrt{\frac{a^2}{4} + b} - \frac{a}{2} \quad (116)$$

Since $\frac{a^2}{4} \gg b$, equation 116 is unwieldy for numerical evaluation. Because t^2 is very much smaller than either of the two other terms in (115), a first approximation for t is found by neglecting the square term in (115):

$$t_1 = \frac{b}{a} \quad (117)$$

or

$$t_1 = \frac{2n_B n_H M}{A F_{tu}} \quad (118)$$

where A is the cross section area $r^2 \pi$ of the cylinder. This approximation, which is slightly conservative, is independent of E and γ . This reflects the fact that the effect of the shell stiffness proper (i.e., at $p = 0$; see first term on the right-hand side of equation 107) usually is very small if compared with the stabilizing effect of the pressure.

Further approximations, if needed, are easily found by means of Newton's method:

According to (115), let:

$$\psi = t^2 + at - b = 0$$

$$\psi' = \frac{d\psi}{dt} = 2t + a$$

Then the second approximation for t is

$$t_2 = t_1 - \frac{\psi_1}{\psi_1}$$

$$= t_1 - \frac{t_1^2 + at_1 - b}{2t_1 + a}$$

and upon simplification

$$t_2 = \frac{b}{a} \frac{a^2 + b}{a^2 + 2b} \quad (119)$$

or

$$t_2 = t_1 \frac{a + t_1}{a + 2t_1} \quad (120)$$

Generally:

$$t_{i+1} = \frac{t_i^2 + b}{2t_i + a} \quad (121)$$

The required limit pressure is found by substitution of either (118) or (120) into (111). In the former case, the first approximation for p is found to be

$$p_1 = \frac{2n_B M}{r^3 \pi} \quad (122)$$

Equation 122 indicates the pressure at which the moment $n_B M$ would produce incipient wrinkling of a pure-membrane cylinder.

The second approximation for the required pressure is

$$p_2 = \frac{2n_B M}{r^3 \pi} \cdot \frac{a + t_1}{a + 2t_1} \quad (123)$$

For given material characteristics, the required thickness, t , is essentially a function of M/A (Reference Equation 118). The lower limit of M/A that still yields a reasonable and available gage - say: $t_{\min} = 0.01$ - is approximately

$$\left(\frac{M}{A}\right)_{\min} = t_{\min} \left(\frac{F_{tu}}{2n_B n_H} \right) \quad (124)$$

For example, if aluminum alloy clad 2024-T4 is used:

$$F_{tu} = 60,000 \text{ psi}$$

$$t_{\min} = 0.01 \text{ in}$$

$$\phi = 0.8 \text{ (assumed)}$$

$$n_B = n_H = 1.5$$

these:

$$\begin{aligned} (M/A)_{\min} &= \frac{0.01 \times 60,000 \cdot 0.8}{4.5} \\ &= 106.7 \text{ lb/in} \\ &= 1280 \text{ lb/ft} \end{aligned}$$

This criterion defines a dividing line between small, slow airships that are to be designed for a moderate gust velocity - these would be penalized in structural weight due to the minimum - gage problem encountered - and larger, faster airships, built for higher gust velocities; for the latter ships, the metal-clad system may potentially offer advantages.

3. MAXIMUM LIMIT BENDING MOMENT IN AIRSHIP OPERATION

The bending moments encountered in severe gusts ($u = 30 \text{ ft/sec}$, normal to the axis of the airship) may be considered representative for the maximum limit bending moment, within the scope of a parametric analysis. *

According to Reference 30 the maximum gust moment is

$$M_g = 0.029 \rho u v \Psi (L/2)^{1/4} \quad (125)$$

(all terms expressed in lb, ft, and sec)

Here:

$$\begin{aligned} \rho &= \text{air density} \\ u &= \text{gust velocity} \\ v &= \text{air speed} \end{aligned}$$

* In a detail analysis, the additional bending moments due to unequal distribution of static lift and weight, heaviness, eccentricity of the longitudinal gas pressure load with respect to the center line, etc., ought to be taken into consideration.

Ψ = displacement volume

L = length of airship

With the relations:

$\bar{q} = \rho u v$ = "effective" dynamic pressure

$\eta = \frac{\Psi}{AL}$ = cylinder coefficient

and with

$L_r = 1000$ ft, an arbitrary length of reference

Equation 125 can be written

$$\frac{M_g}{A} = k \bar{q} L \left(\frac{L}{L_r} \right)^{1/4} \quad (126)$$

where k now is a non-dimensional constant:

$$k = 0.029 \left(\frac{L_r}{2} \right)^{1/4}$$

$$k = 0.137 \quad (127)$$

Substitute M_g/A from (126) for M/A in Equation 118. This gives

$$t_1 = 2k \bar{q} \frac{n_B n_H}{F_t} L \left(\frac{L}{L_r} \right)^{1/4} \quad (128)$$

The corresponding required limit pressure is from equation 111:

$$p_1 = \frac{F_t}{n_H \cdot r} \cdot t_1 \quad (129)$$

Both the equation 128 and 129 represent first approximations for the required wall thickness and pressure, respectively. The second approximations, if needed, are

$$t_2 = t_1 \frac{a + t_1}{a + 2t_1} \quad (130)$$

$$P_2 = P_1 \frac{a + t_1}{a + 2t_1} \quad (131)$$

where a is given by equation 113.

On the triple graph of Figure 40, these relations are plotted for a wide variety of all parameters involved. For use of the graph, calculate the three parameters

$$\eta \bar{q} = \eta_{pu} v \text{ (lb/ft}^2\text{)} \quad (132)$$

$$\xi = \frac{2n_B n_H}{\phi F_{tu}} \text{ (ft}^2\text{/lb)} \quad (133)$$

$$\omega = \frac{\phi F_t}{n_H \cdot r} \text{ (lb/in}^3\text{)} \quad (134)$$

As exemplified in the figure enter the graph at the appropriate value $\eta \bar{q}$ and go clockwise to read M/A (lb/ft), t_1 (in), and p_1 (in H_2O) at the particular parametric values of L , ξ , and ω , respectively.

4. WEIGHT COMPARISON WITH SANDWICH CONSTRUCTION AND FABRIC ENVELOPES (NON-RIGID AIRSHIPS).

A weight parameter that is a function of $\left(\frac{M_{cr}}{r^3}\right)$ can be defined for sandwich hulls in the form

$$\frac{w}{r} = f\left(\frac{M_{cr}}{r^3}\right) \quad (135)$$

It is easy and to the purpose to define the corresponding weight parameter w/r for the single-skin cylinder as well as for the fabric envelope. This procedure makes direct comparison of the (w/r) -values for all three design approaches possible.

In the case on hand, equation 118 may be used. With:

$$u_B \cdot M = M_{cr} \quad (136)$$

and

$$A = r^2 \pi \quad (137)$$

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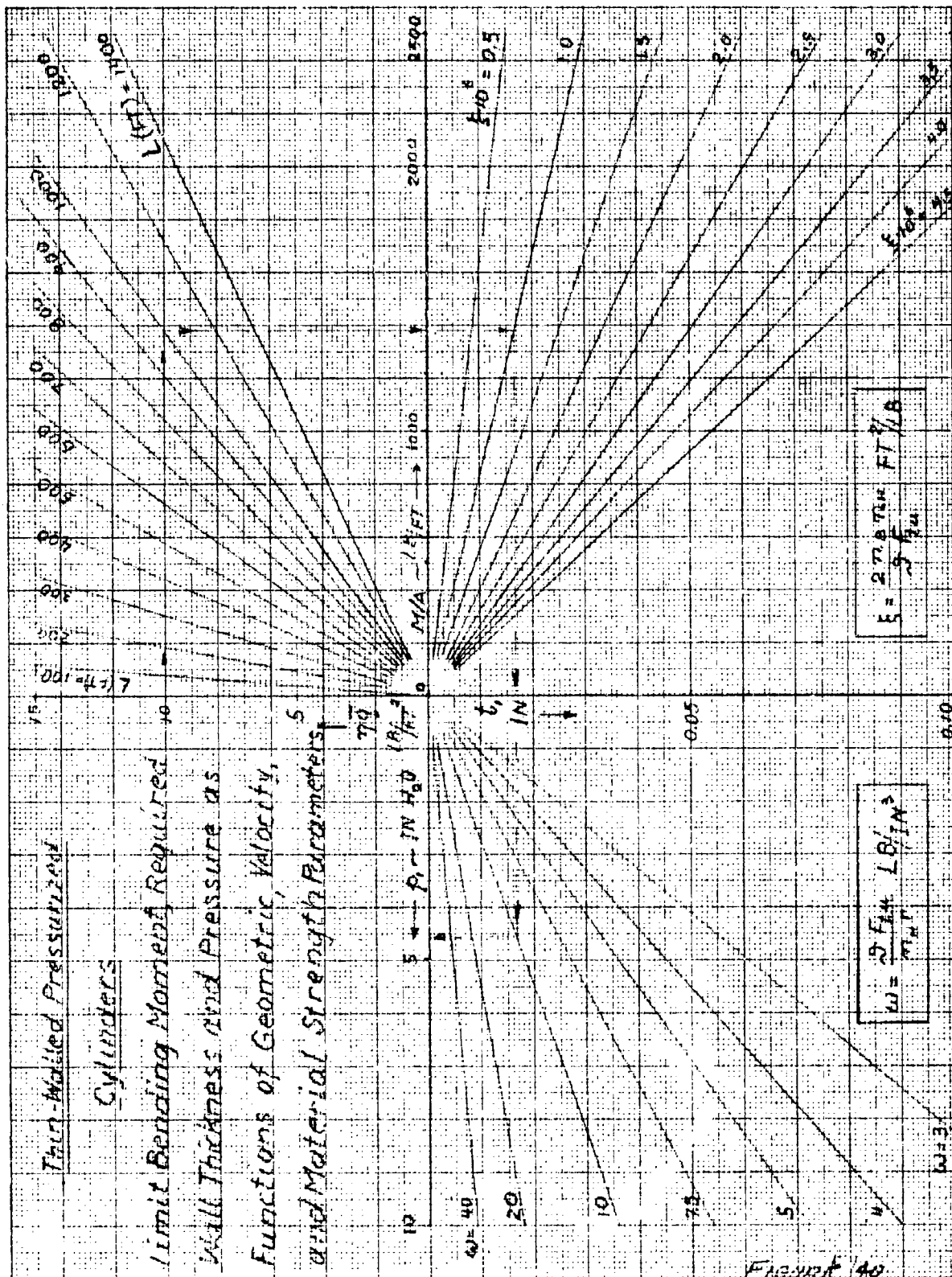


FIGURE 40

one obtains

$$\frac{t_1}{r} = \frac{2n_H}{\pi \phi F_{tu}} \cdot \left(\frac{M_{cr}}{r^3} \right) \quad (138)$$

and

$$\frac{w}{r} = \frac{\rho_{AL} t_1}{r} = \frac{2\rho_{AL} \cdot n_H}{\pi \phi F_{tu}} \left(\frac{M_{cr}}{r^3} \right) \quad (139)$$

Since the term $\frac{M_{cr}}{r^3 F_t}$ is non-dimensional, the weight parameter w/r is

obtained in lb/ft^3 if the unit weight of the material (al. alloy) is expressed in the same units: $\rho_{AL} = 173 \text{ lb/ft}^3$. Thus, with $n_H = 1.5$, $F_t = 60,000$ psi, and $\phi = 0.8$

$$10^3 \cdot \frac{w}{r} \left[\text{lb/ft}^3 \right] = 3.44 \left(\frac{M_{cr}}{r^3} \right) \left[\text{psi} \right] \quad (140)$$

(Reference Figure 44).

5. ESTIMATED WEIGHTS OF PRESSURIZED SANDWICH CYLINDERS SUBJECTED TO BENDING

For a sandwich cylinder having equal face sheet thicknesses at an isotropic material, unpressurized, and subjected to pure bending, the buckling stress is given by (Reference 29, pp. 36-39)

$$\sigma_{cr} = \frac{\gamma k E}{\sqrt{1 - \mu^2}} \left(\frac{h}{r} \right) \quad (141)$$

where γ is a correlation factor accounting for the difference between classical theory and experimental evidence

k is a reduction factor related to the shear stiffness of the core

The expression given for γ is (Reference 29, pp. 26 and 38)

$$= 1 - .731 (1 - e^{-\varphi}) \quad (142)$$

where (Reference 29, p 34)

$$\varphi = \frac{\sqrt{2}}{29.8} \sqrt{\frac{r}{h}} \quad (143)$$

Values for k can be taken from Figure 1.4.5.2b, page 36 of Reference 29.
For the following analysis,

$$k = 1 - \frac{.5\gamma}{\sqrt{1-\mu^2}} \left(\frac{E}{G_c}\right) \left(\frac{t}{r}\right) \left(1 - \frac{t}{h}\right) \quad (144)$$

which corresponds to $(G_{xz}/G_{yz}) \leq 1.0$ and for

$$\frac{2\gamma_{Et}}{\sqrt{1-\mu^2} G_{xz} r} \left(1 - \frac{t}{h}\right) \leq 2.0$$

Assuming that $t/h \ll 1.0$ and substituting equation (144) into 141) gives

$$\sigma_{cr} = \frac{\gamma_E}{\sqrt{1-\mu^2}} \left(\frac{h}{r}\right) \left[1 - \frac{.5\gamma_{E_F} t_F}{\sqrt{1-\mu^2} G_c r} \right] \quad (145)$$

In Reference 31, the minimum weight sandwich cylinder under axial compression is determined to be of that construction for which the core weight is given by

$$w_c = (w - w_B) \left[\frac{1 - k_2 V}{2 - 3k_2 V} \right] \approx \left[(w_c + w_F + w_B) - w_B \right]^{1/2} \quad (146)$$

or

$$w_c/w_F \approx 1 \quad (147)$$

i.e., core weight is approximately equal to the fall sheet weight. Then

$$t_F \approx \frac{\rho_c}{2\rho_F} h \quad (148)$$

With (148) substituted into (145), the buckling stress is given by

$$\sigma_{cr} = \frac{\gamma_E}{\sqrt{1-\mu^2}} \left(\frac{h}{r}\right) \left[1 - \frac{.5\gamma_{E_F} h}{\sqrt{1-\mu^2} G_c r} \left(\frac{1}{2} \frac{\rho_c}{\rho_F}\right) \right] \quad (149)$$

and the buckling moment becomes

$$\begin{aligned}
 M_{cr} &= 2\pi \sigma_{cr} r^2 t = 2\pi r^2 \sigma_{cr} \left(\frac{\rho_c}{\rho_F}\right) h \\
 &= \frac{\pi r^3 E \gamma}{\sqrt{1 - \mu^2}} \left(\frac{\rho_c}{\rho_F}\right) \left(\frac{h}{r}\right)^2 \left[1 - \frac{.25 \gamma E}{\sqrt{1 - \mu^2} G_c} \left(\frac{\rho_c}{\rho_F}\right) \left(\frac{h}{r}\right) \right] \quad (150)
 \end{aligned}$$

or

$$\frac{M_{cr}}{r^3} = \frac{\pi E}{\sqrt{1 - \mu^2}} \left(\frac{\rho_c}{\rho_F}\right) \gamma \left(\frac{h}{r}\right)^2 \left[1 - \frac{.25 E}{G_c \sqrt{1 - \mu^2}} \left(\frac{\rho_c}{\rho_F}\right) \gamma \left(\frac{h}{r}\right) \right] \quad (151)$$

To account for internal pressurization, the buckling moment, $M_{cr(p)}$, is given by (Reference 29, page 20)

$$\frac{M_{cr(p)}}{r^3} = \frac{M_{cr}}{r^3} + 0.8\pi p \quad (152)$$

(For incipient wrinkling, the 0.8 is reduced to 0.5)

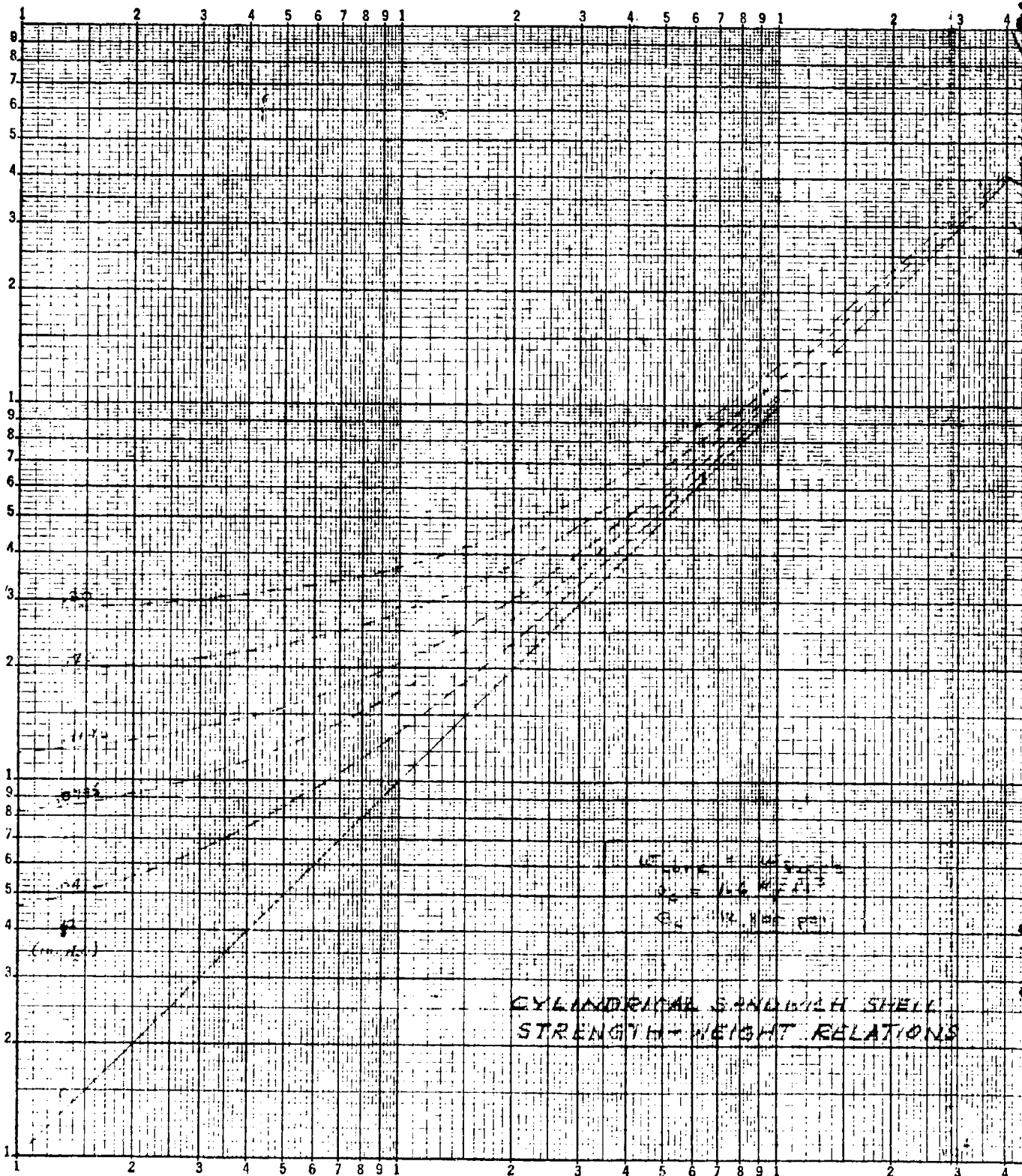
Equations (151) and (152) are plotted in Figure 41 for aluminum face sheet sandwich with a core weight at 1.6 lb/ft³ and a core shear modulus of 12,800 psi. For a given M/r^3 , a required r/h can be determined and therefore the core thickness is found. Although h = core thickness plus face sheet thickness, i. e., $h = t_c + 2t_F$, it was assumed earlier that $t_F/h \ll 1$ so that $t_c/h \approx 1$ or $t_c \approx h$.

With h known, face sheet thickness is found from equation (148) and the total sandwich weight per unit area is given by

$$w_s = 2\rho_F t_F + \rho_c h + w_B \quad (153)$$

The values of h , t_F , and $w - w_B$ are cross plotted on Figure 41. Also plotted on Figure 41 is the total sandwich weight, w_s , for an adhesive weight, w_B , of .08 lb/ft².

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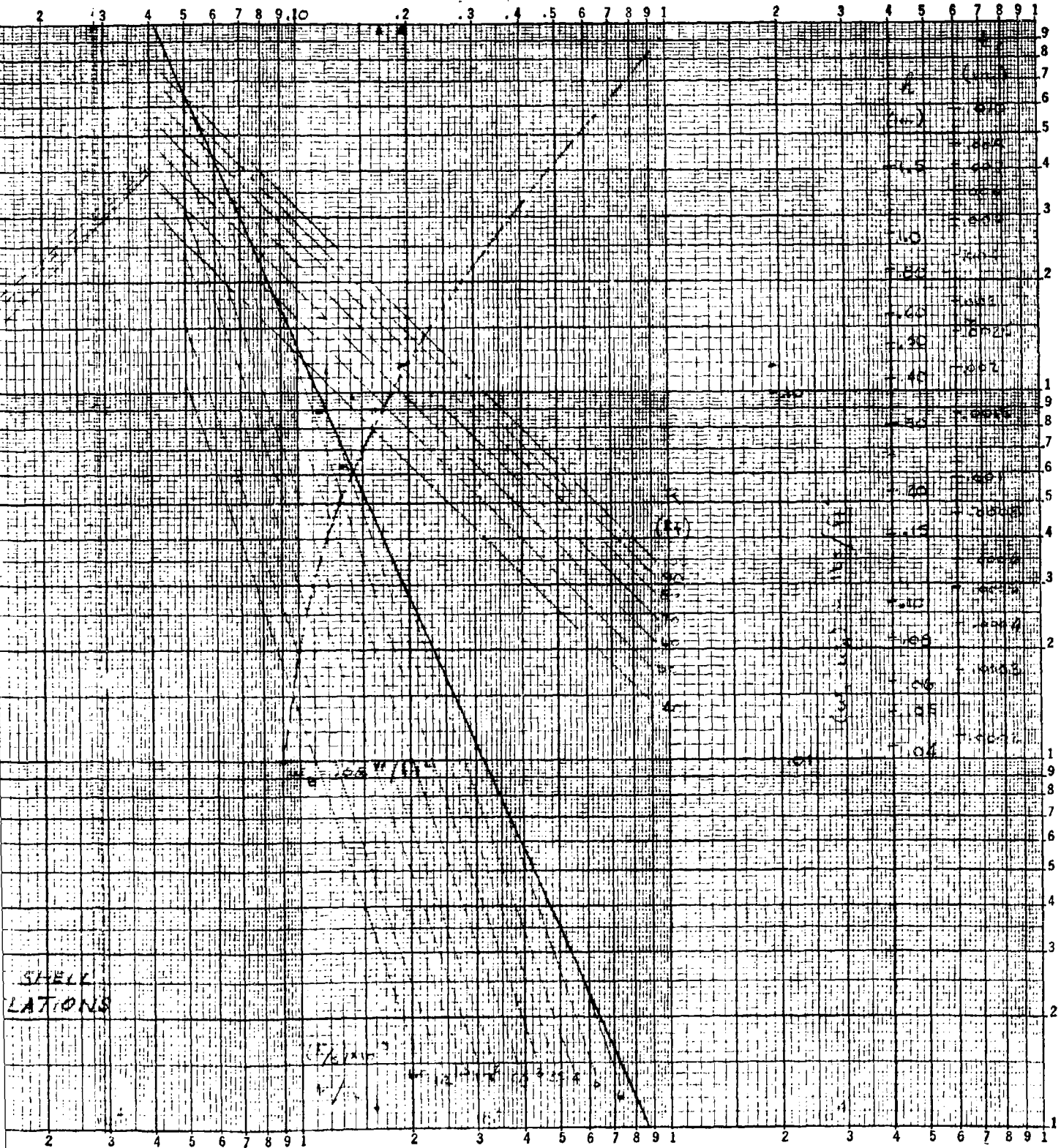


FIGURE 41 B

The cell dimpling criterion is given by (Reference 32)

$$F_d = \frac{2E}{1-\mu^2} \left(\frac{t_F}{s} \right)^2 \quad (154)$$

where s is the cell size and t_F is the face sheet thickness. Using the same core to face sheet weight criterion as before

$$t_F = \frac{1}{2} \left(\frac{\rho_c}{\rho_F} \right) h \quad (155)$$

so that

$$F_d = \frac{E}{2(1-\mu^2)} \left(\frac{\rho_c}{\rho_F} \right)^2 \frac{h^2}{s^2} \quad (156)$$

Then

$$M_{cr} = (2t_F) F_{cr} \pi r^2 = \pi \left(\frac{\rho_c}{\rho_F} \right) h F_{cr} r^2 = \frac{\pi E}{2(1-\mu^2)} \left(\frac{\rho_c}{\rho_F} \right)^3 \frac{h^3 r^2}{s^2} \quad (157)$$

or

$$\frac{M_{cr}}{r^3} = \frac{\pi E}{2(1-\mu^2)} \left(\frac{\rho_c}{\rho_F} \right)^3 \frac{(r/s)^2}{(r/h)^3} \quad (158)$$

For $\rho_c = 1.6 \text{ #/ft}^3 = .000926 \text{ #/in}^3$ and $\rho_F = .101$, and with $E = 10^7$ and $\mu = .3$,

$$\frac{M_{cr}}{r^3} = \frac{\pi(10^7)}{1.82} (.00917)^3 \frac{(r/s)^2}{(r/h)^3} = \frac{24.2246}{1.82} \frac{(r/s)^2}{(r/h)^3} = 13.31 \frac{(r/s)^2}{(r/h)^3}$$

This criterion is identified by the (r/s) lines in Figure 41.

6. BUCKLING CRITERIA AND OPTIMIZATION OF PRESSURIZED SANDWICH CYLINDERS IN BENDING

For the purpose of optimization, the buckling criteria will be used in the form that indicates incipient buckling. Then the critical moments at zero pressure (M_{cr}) and at pressure p [$M_{cr}(p)$] are given by the equations:

$$\frac{M_{cr}}{r^3} = \frac{\pi E}{\sqrt{1-\mu^2}} \frac{\rho_c}{\rho_F} \gamma \left(\frac{h}{r}\right)^2 \left[1 - \frac{0.25E}{\sqrt{1-\mu^2} G_c} \frac{\rho_c}{\rho_F} \gamma \frac{h}{r} \right] \quad (151)$$

and

$$\frac{M_{cr(p)}}{r^3} = \frac{M_{cr}}{r^3} + \frac{1}{2} \pi p \quad (152')$$

Both criteria are applicable when cell dimpling is not critical. Note that p in Equation (152) is the limit pressure, not the critical pressure.

If $M_{cr(p)}$, r , and the material properties are given, the combined Equations (151) and (152) contains the two unknowns h and p . (The correlation factor is a function of r/h , see Reference 29). The problem is to determine, in any particular case, the optimum combination of the parameters h and p .

This combination is defined by either of two additional conditions or limitations, whichever is the more severe, viz.:

(a) The hoop stress at pressure p must be covered by an adequate factor of safety n_H , i. e.:

$$2 t_F \phi F_{tu} = p r n_H \quad (200)$$

where the factor $\phi < 1$ accounts for the effect of fasteners and F_{tu} is the tensile strength in hoop direction;

(b) Failure on the tension side should not occur before buckling on the compression side, in formula:

$$\sigma_{L_{max}} = \frac{M_{cr(p)}}{2 r^2 \pi t_F} + \frac{p r}{4 t_F} = \frac{\phi F_{tu}}{n_L} \quad (201)$$

where $n_L \geq 1$. It is also assumed that there is no significant difference between the net tensile strength in hoop and longitudinal direction, ϕF_{tu} .

Condition a

From (200)

$$p_{(a)} = 2 \frac{t_F}{r} \frac{\phi F_{tu}}{n_H} \quad (202)$$

According to (7):

$$w_c = w_F$$

or

$$\rho_c t_c = 2 \rho_F t_F \quad (203)$$

With

$$2t_F + t_c = h$$

one obtains from (203)

$$2t_F = h \frac{\rho_c}{\rho_F + \rho_c} \quad (204)$$

and from (202)

$$P_{(a)} = \frac{h}{r} \frac{\rho_c}{\rho_F + \rho_c} \frac{\sigma_F t_u}{n_H} \quad (205)$$

or approximately, with neglect of ρ_c in the denominator of (205);

$$P_{(a)} = \frac{h}{r} \frac{\rho_c}{\rho_F} \frac{\sigma_F t_u}{n_H} \quad (206)$$

Substitute (206) into (152') for

$$\left[\frac{M_{cr(p)}}{r^3} \right]_a = \frac{M_{cr}}{r^3} + \frac{\pi}{2} \frac{h}{r} \frac{\rho_c}{\rho_F} \frac{\sigma_F t_u}{n_H} \quad (207)$$

Equation 207 shows $M_{cr(p)}/r^3$ to be a function of (h/r) only if p is selected so that the hoop tension is covered with the specified factor of safety, n_H .

Condition b

From Equation 201:

$$\begin{aligned} P_{(b)} &= \frac{4t_F}{r} \left(\frac{\sigma_F t_u}{n_L} - \frac{M_{cr(p)}}{2r^2 \pi t_F} \right) \\ &= \frac{4t_F}{r} \frac{\sigma_F t_u}{n_L} - \frac{2}{\pi} \frac{M_{cr(p)}}{r^3} \end{aligned} \quad (208)$$

Substitution of (208) into (152') yields

$$\frac{M_{cr(p)}}{r^3} = \frac{M_{cr}}{r^3} + 2\pi t_F \frac{\rho_F t_{tu}}{r n_L} - \frac{M_{cr(p)}}{r^3}$$

or, upon simplification

$$\frac{M_{cr(p)}}{r^3} = \frac{1}{2} \frac{M_{cr}}{r^3} + \pi t_F \frac{\rho_F t_{tu}}{r n_L}$$

and with

$$t_F \approx \frac{h}{2} \frac{\rho_c}{\rho_F} \quad (209)$$

$$\left[\frac{M_{cr(p)}}{r^3} \right]_b = \frac{1}{2} \frac{M_{cr}}{r^3} + \frac{\pi}{2} \frac{h}{r} \frac{\rho_c}{\rho_F} \frac{\rho_F t_{tu}}{n_L} \quad (210)$$

A "cross-over" point, at which Condition b will start to overrule Condition a or vice versa, may occur when the critical moments of the pressurized cylinder as given by (207) and (210) becomes equal. Equations (207) and (210) yields the "border line" value $(M_{cr}/r^3)_B$, which divides the ranges of validity of Equations (207) and (209):

$$\left(\frac{M_{cr}}{r^3} \right)_B = \pi \frac{h}{r} \frac{\rho_c}{\rho_F} \rho_F t_{tu} \left(\frac{1}{n_L} - \frac{1}{n_H} \right) \quad (211)$$

An example will clarify these relations. Let $h/r = 1/1000$. The numerical values used in the equations are:

$$E = 10 \times 10^6 \text{ psi (faces)}$$

$$G_c = 12,800 \text{ psi (core)}$$

$$\mu = 0.3$$

$$\sqrt{1 - \mu^2} = 0.955$$

$$\gamma = 0.432 \text{ (for } h/e = 1/1000)$$

$$\rho_c = 1.6 \text{ lb/ft}^3$$

$$\rho_F = 173 \text{ lb/ft}^3$$

$$\rho_c/\rho_F = 0.00924$$

$$F_{tu} = 60,000 \text{ psi}$$

$$\rho = 0.8$$

$$n_H = 1.5$$

$$n_L = 1.2$$

Then the moment parameter at zero pressure is (Reference, Equation 151):

$$\frac{M_{cr}}{r^3} = \frac{\pi \times 10^7}{0.955} \times 0.00924 \times 0.432 \times 10^{-6} \left[1 - \frac{0.25 \times 10^7 \times 0.00924 \times 0.432}{0.955 \times 12,800 \times 1000} \right]$$

$$= 0.1312 \text{ psi} = 18.9 \text{ lb/ft}^2$$

Condition a then would require the pressure

$$p_a = \frac{1}{1000} \times 0.00924 \times 32,000$$

(Reference, Equation 206)

$$= 0.2955 \text{ psi}$$

$$= 8.18 \text{ in. H}_2\text{O.}$$

The critical moment at that pressure is given by

$$\left[\frac{M_{cr(p)}}{r^3} \right]_a = 0.1312 + \frac{\pi}{2} 0.2955 = 0.5957 \text{ psi}$$

$$= 85.8 \text{ lb/ft}^2$$

On the other hand, the critical moment parameter at pressure p_b would be, according to (209):

$$\left[\frac{M_{cr(p)}}{r^3} \right]_b = 0.0656 + \frac{\pi}{2} \times 10^{-3} \times 0.00924 \times 40,000$$

$$= 0.6466 \text{ psi}$$

$$= 93.1 \text{ lb/ft}^2$$

and the pressure would be (Reference, Equation 208 and 204)

$$p_b = \frac{2h_c^2 F_{tu}}{r_F n_L} - \left[\frac{2}{\pi} \frac{M_{cr(p)}}{r^3} \right]_b$$

$$= \frac{2}{1000} 0.00924 \times 40,000 - \frac{2}{\pi} \times 0.6466$$

$$= 0.327 \text{ psi}$$

$$= 9.06 \text{ in H}_2\text{O.}$$

Since $p_b > p_a$ the hoop stresses due to p_b would not be covered with the specified safety factor n_H , and it is seen that, in this case, Condition a overrules Condition b. Therefore, the maximum allowable critical moment is

$$\left[M_{cr(p)} \right]_a = 85.8 r^3 \text{ ft. lb.}$$

and requires pressurization to

$$p_a = 8.18 \text{ of water}$$

The correlation factor j is given by

$$\gamma = 1 - 0.731(1 - e^{-\phi}) \quad (212)$$

where

$$\begin{aligned} \phi &= \frac{\sqrt{2}}{29.8} \sqrt{r/h} \\ &= 0.0475 \sqrt{r/h} \quad (\text{Reference 29}) \end{aligned} \quad (213)$$

With these relations and the numerical data given above, the evaluation yields the results compiled in Table V-26.

Table V-26 indicates - as is to be expected - that for the smaller values of h/r the hoop stress limitation (Condition a) is dominant, whereas for the thicker sandwiches and correspondingly higher moment parameters $M_{cr(p)}/r^3$, the maximum longitudinal tensile stress is the determinative parameter (Condition b). The transition point is approximately at the thickness \div radius ratio $h/r = 1/650$.

The last column of Table V-26 gives the ratios

$$\frac{M_{cr(p)}}{M_{cr(p=0)}} = 1 + \frac{\pi p}{2 \frac{M_{cr(p=0)}}{r^3}} \quad (214)$$

This ratio represents an indicator of how much the efficiency of the structure in bending is augmented by the pressurization, with no structural weight added.

TABLE V-26
OPTIMUM CORRELATION OF SANDWICH THICKNESS,
BUCKLING MOMENT AND PRESSURE

h/r	ϕ	γ	$\frac{M_{cr(p=o)}}{r^3}$	$\frac{M_{cr(p)}}{r^3}$	psi "b"	P, "a"	In H ₂ O "b"	$\frac{M_{cr(p)}}{M_{cr(p=o)}}$
			psi	"a"				
1/500	1.063	0.521	0.633	1.562	1.476		14.84	2.33
1/600	1.164	0.499	0.421	1.195	1.178		13.41	2.80
1/700	1.258	0.477	0.296	0.959	0.977	11.68		3.21
1/800	1.344	0.460	0.219	0.799	0.835	10.22		3.65
1/900	1.425	0.445	0.167	0.683	0.729	9.07		4.09
1/1000	1.502	0.432	0.132	0.596	0.646	8.18		4.51
1/2000	2.125	0.347	0.0263	0.259	0.303	4.10		9.85
1/3000	2.600	0.322	0.0109	0.1656	0.199	2.73		15.2
1/4000	3.000	0.304	0.0058	0.1218	0.148	2.05		21.0
1/5000	3.360	0.295	0.0036	0.0964	0.118	1.64		26.8

7. CELL DIMPLING CRITERIA

Dimpling may occur prior to general instability failure unless the core cell size is equal to, or less than a certain critical cell size, which is found as follows:

The dimpling stress is given by Reference 32 as

$$F_d = \frac{2E}{1-\mu} \left(\frac{t_F}{s} \right)^2 \quad (215)$$

where t_F is the face sheet thickness, and s the cell size (= diameter of the largest circle that can be inscribed in the cell).

Substitute Equation 209 into 215:

$$F_d = \frac{E}{2(1-\mu)} \left(\frac{R_c}{R_F} \right)^2 \left(\frac{h}{s} \right)^2 \quad (216)$$

The bending moment that produces dimpling at zero pressure is

$$\begin{aligned} M_{d(p=0)} &= 2\pi r^2 t F_d \\ &= \pi r^2 \frac{\rho_c}{\rho_F} h F_d \\ &= \frac{\pi E}{2(1-\mu^2)} \left(\frac{\rho_c}{\rho_F} \right)^3 \left(\frac{h^3 r^2}{s^2} \right) \end{aligned} \quad (217)$$

or

$$\frac{M_{d(p=0)}}{r^3} = \frac{\pi E}{2(1-\mu^2)} \left(\frac{\rho_c}{\rho_F} \right)^3 \frac{(r/s)^2}{(r/h)^3} \quad (218)$$

Equate $M_{d(p=0)}/r^3$ from (218) to $M_{cr(p=0)}/r^3$ from (151), so that general instability failure (buckling) and dimpling occur at the same load level, and solve for (s/r) :

$$\left(\frac{s}{r} \right)_{\max \text{ all}} = \left[\frac{\pi}{2} \frac{E}{(1-\mu^2)} \frac{\frac{h}{r} \left(\frac{\rho_c}{\rho_F} \right)^3}{\frac{M_{cr(p=0)}}{r^3}} \right]^{1/2} \quad (219)$$

This gives, with the numerical values of page 218,

$$\left(\frac{s}{r} \right)_{\max \text{ all}} = 3.69 \left[\frac{(h/r)^3}{M_{cr/r^3}(p=0)} \right]^{1/2} \quad (220)$$

where (M_{cr/r^3}) is to be expressed in psi. Numerical results are listed in Table V-27.

8. WEIGHTS - SANDWICH

The weight of the sandwich per unit surface area is

$$w_s = w_F + w_c + w_B$$

where the subscripts refer to the faces, the core and the bonding agent, respectively.

$$w_s = 2t_F \rho_F + h \rho_c + w_B$$

TABLE V-27
MAXIMUM ALLOWABLE CELL SIZE RATIOS

h/r	$\frac{M_{cr(p=o)}}{r^3}, \text{ psi}$	$(s/r)_{\max} \times 10^3$
1/500	0.633	0.415
1/600	0.421	0.387
1/700	0.296	0.366
1/800	0.219	0.349
1/900	0.167	0.335
1/1000	0.132	0.321
1/2000	0.0263	0.254
1/3000	0.0109	0.215
1/4000	0.0058	0.192
1/5000	0.0036	0.174

or with

$$2t_F = h \frac{\rho_c}{\rho_F}$$

$$w_s = 2h\rho_c + w_B \quad (221)$$

The weight of the bonding agent is considered a constant and taken as

$$w_B = 0.08 \text{ lb/ft}^2$$

Thus, with $\rho_c = 1.6 \text{ lb/ft}^3$

$$w(\text{lb/ft}^2) = 3.2 h(\text{ft}) + 0.08$$

$$= 0.2665 h(\text{in}) + 0.08 \quad (222)$$

9. GRAPHIC CORRELATION OF OPTIMUM SANDWICH PARAMETERS

On Figure 42 the moment parameter $M_{cr(p)}/r^3$ is plotted versus the thickness ratio h/r , also the corresponding optimum limit pressure p , the maximum allowable cell size ratio s/r (precluding premature dimpling); furthermore the optimum sandwich thickness h , face sheet thickness t_F , and total sandwich weight per unit surface area.

If the bending moment in gusts can be considered representative of the maximum limit moment that has to be sustained by the structure, calculate $M_g/A = Mg/r^2 \pi$ from Equation (126), or read its value (in lb/ft) from the graph, Figure 40 in the same section. Note that M_g is a limit moment. The numerical value of $M_{cr(p)}/r^3$ (psi) with which to enter the graph of Figure 42 then is

$$\frac{M_{cr(p)}}{r^3} \text{ (psi)} = \frac{\pi n_g}{144} \frac{(M_g/A) \text{ (ft lb)}}{r \text{ (ft)}}$$

where n_g is the specified safety factor for the gust load condition.

10. EFFECT OF A VARIATION IN CORE THICKNESS

a. General

So far, the analysis and optimization procedure was based on the fact (stated in Reference 31) that minimum weight of a sandwich cylinder in axial compression is attained when the weights per unit surface area of the faces and of the core are equal:

$$w_c = w_F$$

In the particular case on hand, however, it is of interest to determine what effect a different ratio w_c/w_F may have, say:

$$w_c = 1.2 w_F \quad (223)$$

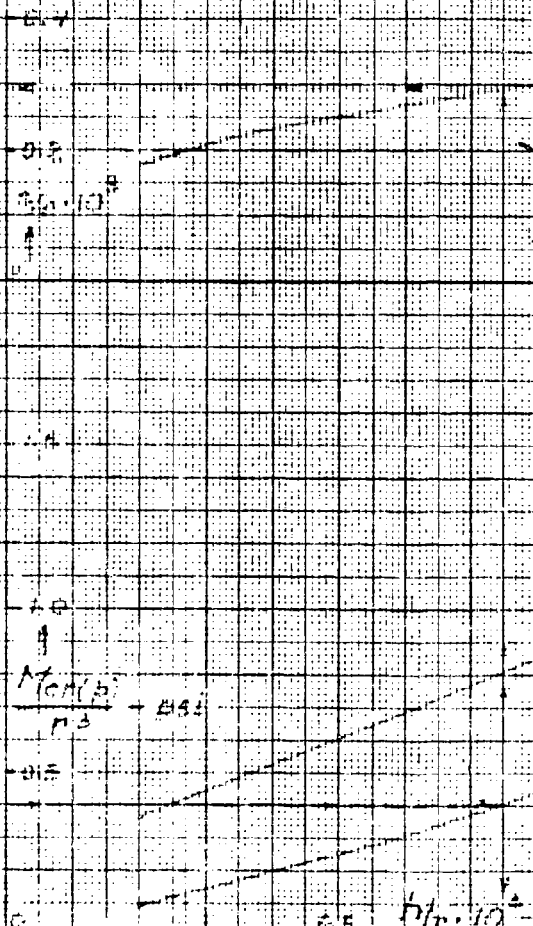
The ratio face sheet thickness ÷ total thickness then will be

$$\begin{aligned} \frac{t_F}{h} &= \frac{1}{2 \times 1.2} \frac{\rho_c}{\rho_F} \\ &= 0.417 \frac{\rho_c}{\rho_F} \end{aligned} \quad (224)$$

The values of ϕ and γ as functions of r/h remain unchanged (Reference, Equations 142 and 143). The effect on $\sigma_{cr(p=0)}$ and $M_{cr(p=0)}$ is almost imperceptible, since the term

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$W = 1.0$	$t_p = 1.0$	
0.347	0.005	
0.515	0.0075	
0.645	0.01	
0.845	0.0133	

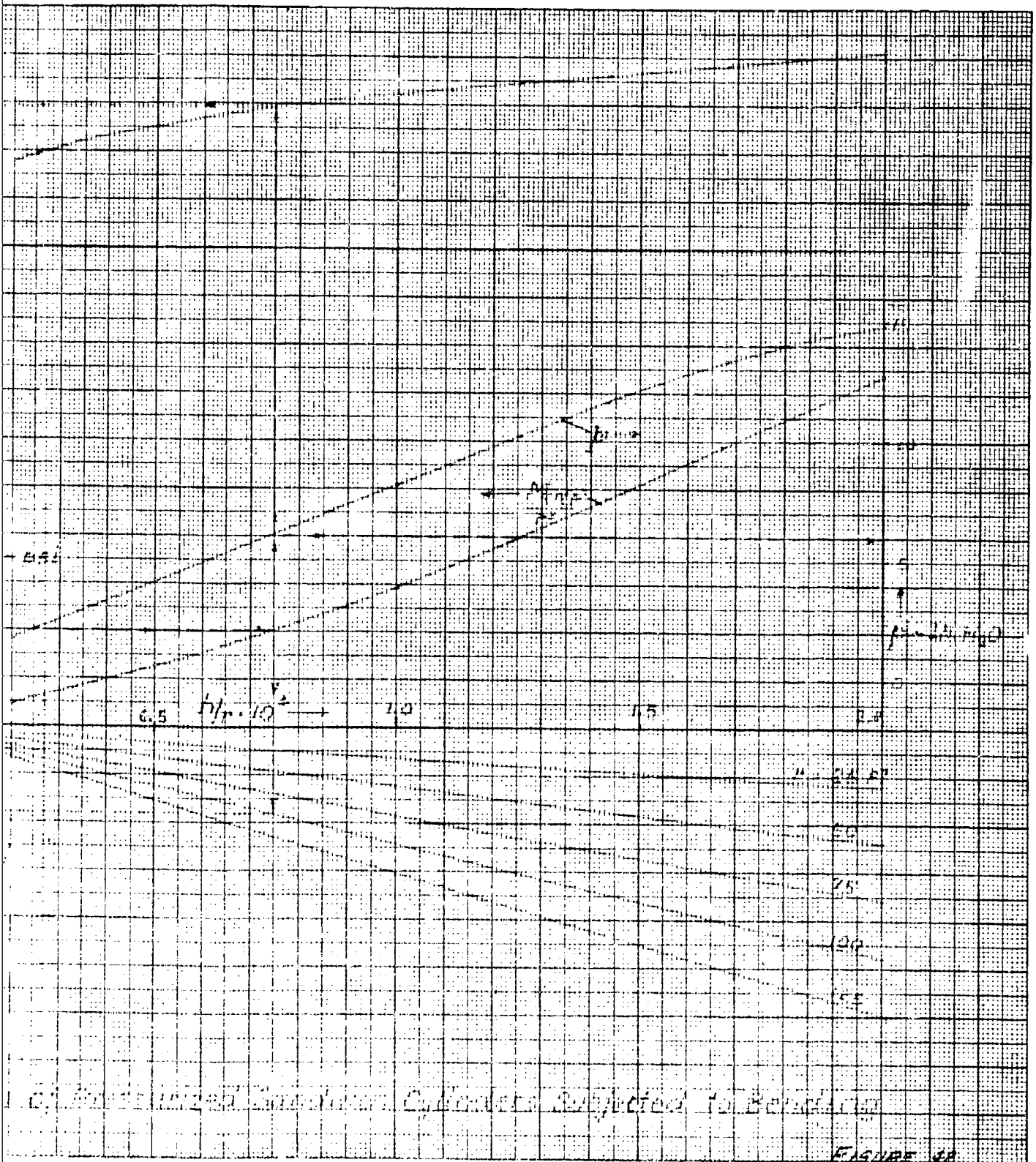
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Graph of Prescribed Spherical Coordinates Applied to Bending

FIGURE 48

B

$$\frac{0.5 \gamma_{Et_F}}{\sqrt{1 - \mu^2 G_c r}}$$

in Equation 145 is nearly negligible in comparison to unity.

The limit pressure, p , does change, and therefore also the critical moment $M_{cr(p)}$, since, for any given h/r , less face cross section is available to sustain the hoop stresses as well as the longitudinal tensile stresses.

The hoop stress limitation (Condition a)

Substitute (224) into (202) for

$$p_{(a)} = 0.834 \frac{h \rho_c \sigma_{Ftu}}{r \rho_F n_H} \quad (225)$$

Then the buckling moment at pressure $p_{(a)}$ is given by

$$\left[\frac{M_{cr(p)}}{r^3} \right]_a = \frac{M_{cr}}{r^3} + 0.417\pi \frac{h \rho_c \sigma_{Ftu}}{r \rho_F n_H} \quad (226)$$

The longitudinal stress limitation (Condition b)

Equation 208 for the allowable pressure $p_{(b)}$ is still valid. Substitution of (208) into (152') yields

$$\frac{M_{cr(p)}}{r^3} = \frac{1}{2} \frac{M_{cr}}{r^3} + \frac{\pi t_F \sigma_{Ftu}}{r n_L}$$

and upon elimination of t_F by means of (224):

$$\left[\frac{M_{cr(p)}}{r^3} \right]_b = \frac{1}{2} \frac{M_{cr}}{r^3} + 0.417\pi \frac{h \rho_c \sigma_{Ftu}}{r \rho_F n_L} \quad (227)$$

As before, the lower of the two values of $M_{cr(p)}/r^3$ given by Equations (226) and (227) is valid.

The results are listed in Table V-28.

TABLE V-28
OPTIMUM CORRELATION OF SANDWICH THICKNESS,
BUCKLING MOMENT, AND PRESSURE
(for $w_c = 1.2 w_F$)

h/r	$\frac{M_{cr(p=o)}}{r^3}, \text{ psi}$	$\frac{M_{cr(p)}}{r^3}, \text{ psi}$	p limit in H_2O	$\frac{M_{cr(p)}}{M_{cr(p=o)}}$
1/500	0.633	1.284	11.52	2.03
1/600	0.421	1.017	10.55	2.42
1/700	0.296	0.840	9.62	2.84
1/800	0.219	0.703	8.53	3.21
1/900	0.167	0.597	7.58	3.57
1/1000	0.132	0.519	6.83	3.93
1/2000	0.0263	0.220	3.41	8.37
1/3000	0.0109	0.140	2.28	12.85
1/4000	0.0058	0.103	1.71	17.76
1/5000	0.0036	0.081	1.37	22.50

b. Cell Dimpling Criteria

Eliminate t_F from (215) by means of (224), which gives the dimpling stress:

$$F_d = 0.347 \frac{E}{1 - \mu} \left(\frac{\rho_c}{\rho_F} \right)^2 \left(\frac{h}{s} \right)^2 \quad (228)$$

The dimpling moment at zero pressure is

$$\begin{aligned} M_{d(p=o)} &= 2\pi r^2 t_F F_d \\ &= 2 \times 0.417\pi r^2 \frac{\rho_c}{\rho_F} h F_d \\ &= 0.834\pi r^2 \times 0.347 \frac{E}{1 - \mu} \left(\frac{\rho_c}{\rho_F} \right)^3 \frac{h^3}{s^2} \end{aligned}$$

and

$$\frac{M_{d(p=0)}}{r^3} = 0.289\pi \frac{E}{1-\mu^2} \left(\frac{\rho_c}{\rho_F}\right)^3 \left(\frac{r/s}{r/h}\right)^2 \quad (229)$$

Equate $M_{d(p=0)}/r^3$ to $M_{cr(p=0)}/r^3$ and solve (229) for s/r :

$$(s/r)_{\max \text{ all.}} = \left[0.289\pi \frac{E}{1-\mu^2} \left(\frac{\rho_c}{\rho_F}\right)^3 \frac{(h/r)^3}{\left(\frac{M_{cr}}{r^3}\right)_{p=0}} \right]^{1/2} \quad (230)$$

This yields, with the same numerical data as used in the previous calculations:

$$(s/r)_{\max \text{ all}} = 2.81 \left[\frac{(h/r)^3}{\frac{M_{cr(p=0)}}{r^3}} \right]^{1/2} \quad (231)$$

$[M_{cr(p=0)}/r^3$ to be expressed in psi].

A comparison of (231) with (220) shows that the thicker core ($w_c = 1.2 w_F$) commands a reduction of the maximum allowable cell size as found for $w_c = w_F$ to

$$(2.81/3.69) \times 100 = 76.2 \text{ pct.}$$

The results are shown in Table V-29.

c. Weights - Sandwich with Thicker Core

From

$$w = 2t_F \rho_F + h \rho_c + w_B$$

and

$$w_c = h \rho_c = 1.2 w_F$$

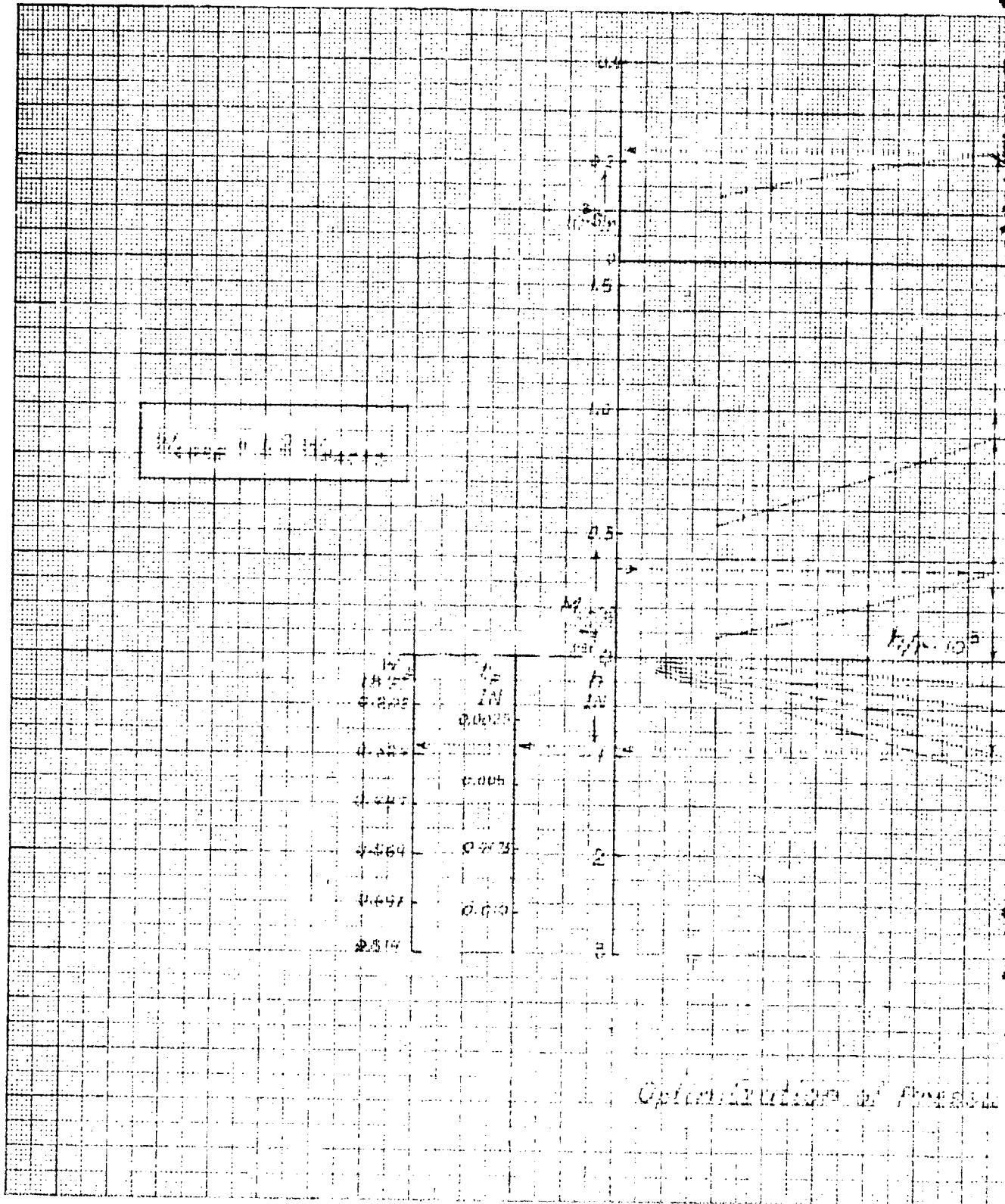
the weight of the sandwich per unit surface area is found to be

$$w \text{ (lb/ft}^2\text{)} = 2.93 h \text{ (ft)} + 0.08$$

$$= 0.2442 h \text{ (in)} + 0.08$$

The correlation of the various sandwich parameters is illustrated on Figure 43 similarly as was done in Figure 42 for the weight ratio $w_c/w_F = 1.0$.

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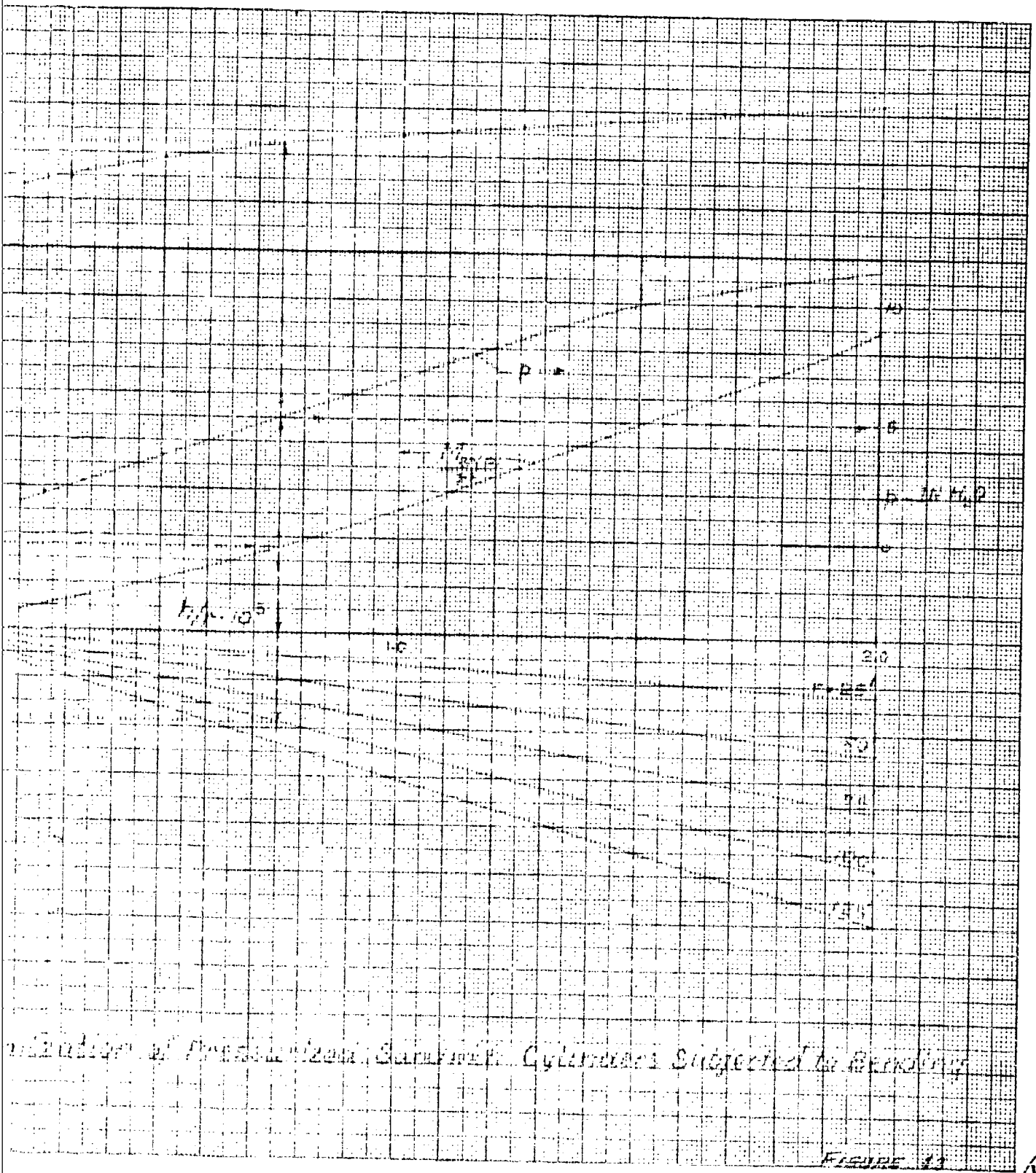


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Relationship of Pressurization, Surface Cylinders Subjected to Bending

FIGURE 13

B

TABLE V-29
MAXIMUM ALLOWABLE CELL SIZE RATIOS
(for $w_c = 1.2 w_f$)

h/r	$(s/r)_{\max} \times 10^3$
1/500	0.316
1/600	0.295
1/700	0.279
1/800	0.266
1/900	0.255
1/1000	0.244
1/2000	0.193
1/3000	0.164
1/4000	0.146
1/5000	0.133

For the purpose of a direct comparison, the weight parameter $(w_c + w_f)/r$ is plotted on Figure 44 vs. the moment parameter $M_{cr(p)}/r^3$, for both values $w_c/w_f = 1.0$ and 1.2 . The weight of the bonding agent is not included.

The weight increase for the sandwich with the thicker core ($w_c/w_f = 1.2$) is approximately 8.2 pct for small values of $M_{cr(p)}/r^3 (= 0.1)$, but only about 2.5 pct for $M_{cr(p)}/r^3 = 1.0$. Inclusion of the bond weight would reduce both percentages.

11. FLEXURAL STRENGTH AND OPTIMIZATION OF PRESSURIZED FABRIC CYLINDERS IN APPLICATION TO NON-RIGID AIRSHIPS

a. Introduction

The analysis and design principles pertaining to fabric structures in general and to non-rigid airships in particular differ in several respects from those applicable to metal structures. Some of the more important aspects are:

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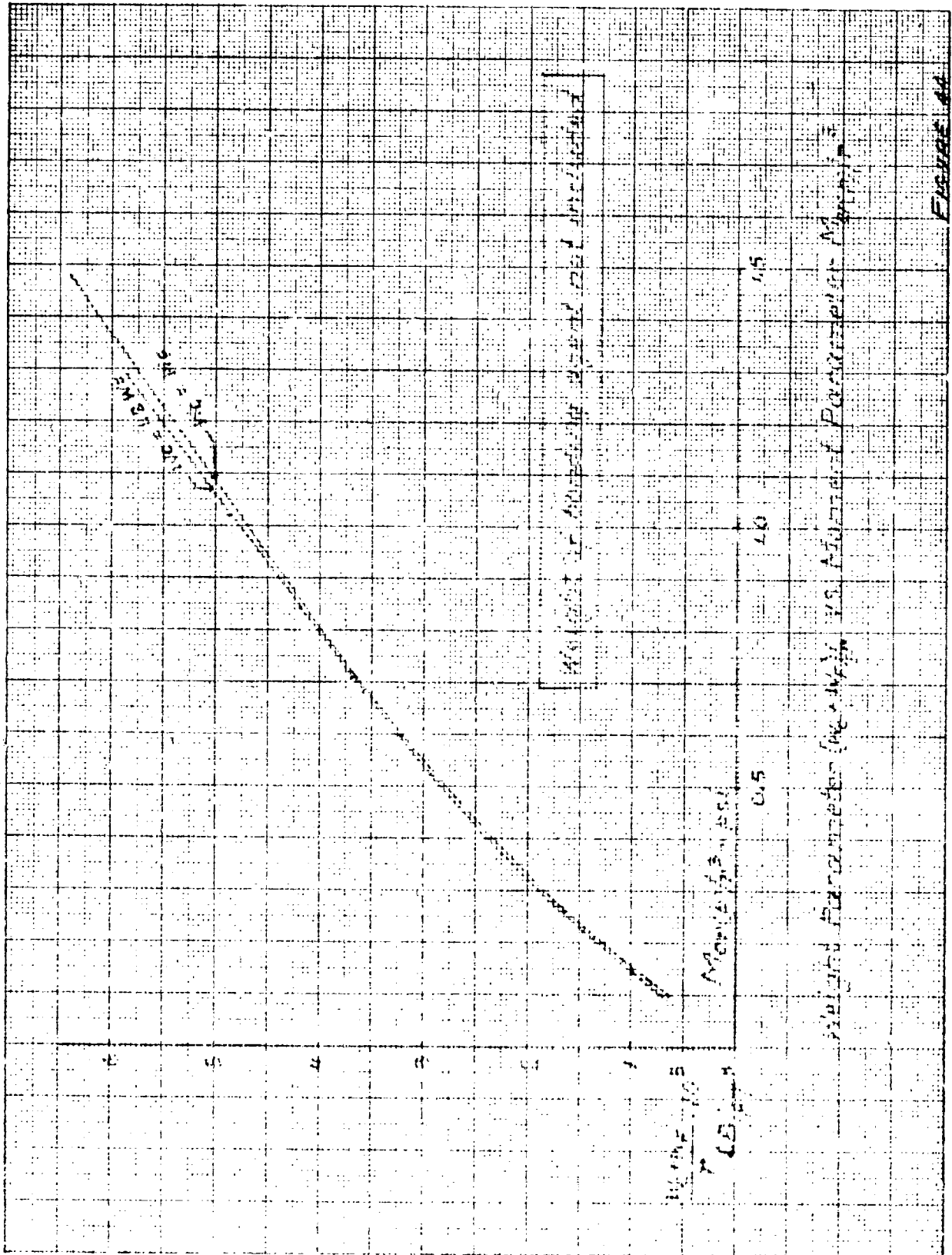


FIGURE 44

1. Stresses and elastic moduli are customarily and conveniently expressed in terms of membrane stresses (load per unit of width, lb/in). This eliminates the need for introduction of the hard-to-define thickness of the fabric as a parameter.
2. All fabrics are either orthotropic or aeolotropic materials. The principal stresses at any point of the envelope may vary in their ratio and orientation over a fairly wide range, depending on the load conditions. It is possible to design the fabric so that optimum efficiency is obtained for just one combination of principal-stress ratio and orientation, but not for more than one. Thus the "effective strength" of a fabric in any particular direction is a function of the ratio as well as of the orientation of the principal stresses.
3. All elastomer-sealed fabrics made of organic (natural or synthetic) fibers and yarns known so far, are subject to creep and strain hysteresis. Creep must be controlled in order that premature fabric deterioration and excessive helium diffusion rates be precluded. This required "safety factors" which are considerably higher than those usually present in light-weight metal structures. Experience has shown that in normal flight conditions (e. g. maneuvering loads), a factor of safety of 4.5, referred to the effective fabric strength, is adequate. In severe load conditions, such as a counteracted gust with $u \geq 30$ ft/sec at N. R. P. speed, a S. F. = 4.0 is considered satisfactory, because of the relative infrequency of such load conditions.
4. If severe gust conditions, such as defined in the preceding paragraph, are specified, incipient wrinkling of the envelope on the compression side is permissible

under the limit gust moment, since the collapse moment is usually nearly twice the incipient-wrinkling moment, and because occasional slight wrinkles are not harmful to the fabric. In this regard, a fabric envelope is better off than a metal (single sheet or sandwich) envelope.

5. The pressure differential of a helium-inflated envelope has a gradient in the z -direction equal to $\partial p / \partial z = c$ where c is the unit lift of the inflation gas (0.0635 lbs/ft³). Within the scope of this parametric study, the limit pressure, p , as it appears in the equations, is the pressure at the equator level of the airship.
6. The hoop tension in any cross section and for a given pressure p is, in general, variable around the circumference. The gradient of the hoop tension, $\partial N_H / \partial z$, is always linear; it is given by (Reference 33)

$$\frac{\partial N_H}{\partial z} = w_f - q_0$$

where w_f is the weight of the fabric per unit area, and q_0 the increment in shear flow per unit length of the envelope, at that point of the cross-section contour which has a vertical tangent.

Thus, if a one foot wide slice of the envelope on which a load greater than the net static lift of the slice acts at the bottom, the shear flow increment, q_0 , will be positive (i.e. directed upward) for equilibrium and $q_0 > w_f$, the gradient $\partial N_H / \partial z$ is negative, the maximum hoop tension occurs at the bottom of the envelope (more exactly, at the line of attachment of the external car suspension system) and the minimum occurs at the top.

If on the other hand, no load at all is applied, the net static lift of the envelope slice must be counteracted, for equilibrium, by negative shear flows; the gradient $\partial N_H / \partial z$ is positive, and the minimum hoop tension occurs at the bottom, the maximum at the top.

For the purpose of obtaining comparable weight data, it suffices to take $N_H = rp$ as the average hoop stress. In fact, this hoop stress is usually found to occur at or near the equator.

b. Analysis

The comparative structural efficiency of various fabrics can be judged on the basis of the breaking length, L_T , which is the length of a vertically suspended fabric strip at which it will rupture under its own weight:

$$L_T = \frac{F_{tu}}{w_f} \quad (300)$$

Here F_{tu} (lb/in) is the ultimate tensile strength in quick loading, and w_f the fabric weight per unit area.

The ultimate strength-to-weight ratio of a series of Dacron-Neoprene fabrics, for instance, is

$$\begin{aligned} L_T = \frac{F_{tu}}{w_f} &= 24 \frac{\text{lb/in}}{\text{oz/yd}^2} \\ &= 41,500 \text{ ft} \end{aligned} \quad (301)$$

With respect to the circumstances pointed out in Item "2" above, a reduced ultimate tensile strength ϕF_{tu} ought to be used in the analysis. With $\phi = 0.8$

$$\phi L_T = 33,000 \text{ ft} \quad (302)$$

The combined minimum longitudinal stress due to a moment M and a pressure p is

$$N_{Lmin} = -\frac{M}{r^2 \pi} + \frac{pr}{2} \quad (303)$$

If the incipient wrinkling under the severest expected bending moment is permitted, then

$$N_{Lmin} = 0$$

and

$$p = \frac{2M}{r^2 \pi} \quad (304)$$

The corresponding hoop tension - which, in this case, equals the maximum longitudinal tension due to the combined effect of moment and pressure - is

$$N_H = \frac{M_{wr}}{r^2 \pi} = \frac{\phi F_{tu}}{n_H} \quad (305)$$

With

$$F_{tu} = w \cdot L_T \quad (306)$$

it follows

$$w = 2 \frac{n_H M_{wr}}{\phi L_T r^2 \pi} \quad (307)$$

This relation can be made directly comparable to the one found for pressurized sandwich hulls by writing it in the form

$$\frac{w}{r} = \frac{2 n_H}{\phi L_T \pi} \frac{M_{wr}}{r^3} \quad (308)$$

(Reference, Figures 42 and 43).

If w/r is expressed in lb/ft^3 , L_T in ft, and (M_{wr}/r^3) in psi then, with

$$n_H = 4.0$$

and

$$\phi L_T = 33,000 \text{ ft}$$

the weight ratio becomes

$$\frac{w}{r} (\text{lb}/\text{ft}^3) = \frac{2 \times 4 \times 144}{33,000 \pi} \left(\frac{M_{wr}}{r^3} \right) \text{psi}$$

or

$$10^3 \times \frac{w}{r} (\text{lb}/\text{ft}^3) = 11.1 \left(\frac{M_{wr}}{r^3} \right) \text{psi} \quad (309)$$

(See Figure 45).

12. COMPARISON OF SINGLE-SKIN, SANDWICH, AND FABRIC DESIGN WEIGHTS, AND DISCUSSION OF RESULTS

Figure 45 shows that the single-skin design yields the lowest net envelope weight parameters w/r throughout the entire range of $M_{cr(p)}/r^3$. Whereas the w/r values for sandwich construction are moderately higher, the Dacron-Neoprene envelope requires considerably higher w/r values. The reason for this becomes clear when the limit-stress-over-weight ratios for both materials (aluminum alloy clad 2024-T4 and Dacron-Neoprene) are compared.

For aluminum:

$$\begin{aligned} \frac{\sigma_{F_{tu}(\text{psi})}}{n_H \rho_{AL}} &= \frac{0.8 \times 60,000}{1.5 \times 0.1} \\ &= 320,000 \text{ in.} \\ &= 26,700 \text{ ft.} \end{aligned}$$

For Dacron-Neoprene:

$$\begin{aligned} \frac{\sigma_{F_{tu}(\text{lb/in})}}{n_H W} &= \frac{\sigma_{L_T}}{n_H} = \frac{33,000}{4} \\ &= 8250 \text{ ft} \end{aligned}$$

(Reference Equation 302).

The ratio of the two values is

$$\frac{26,700}{8,250} = 3.23$$

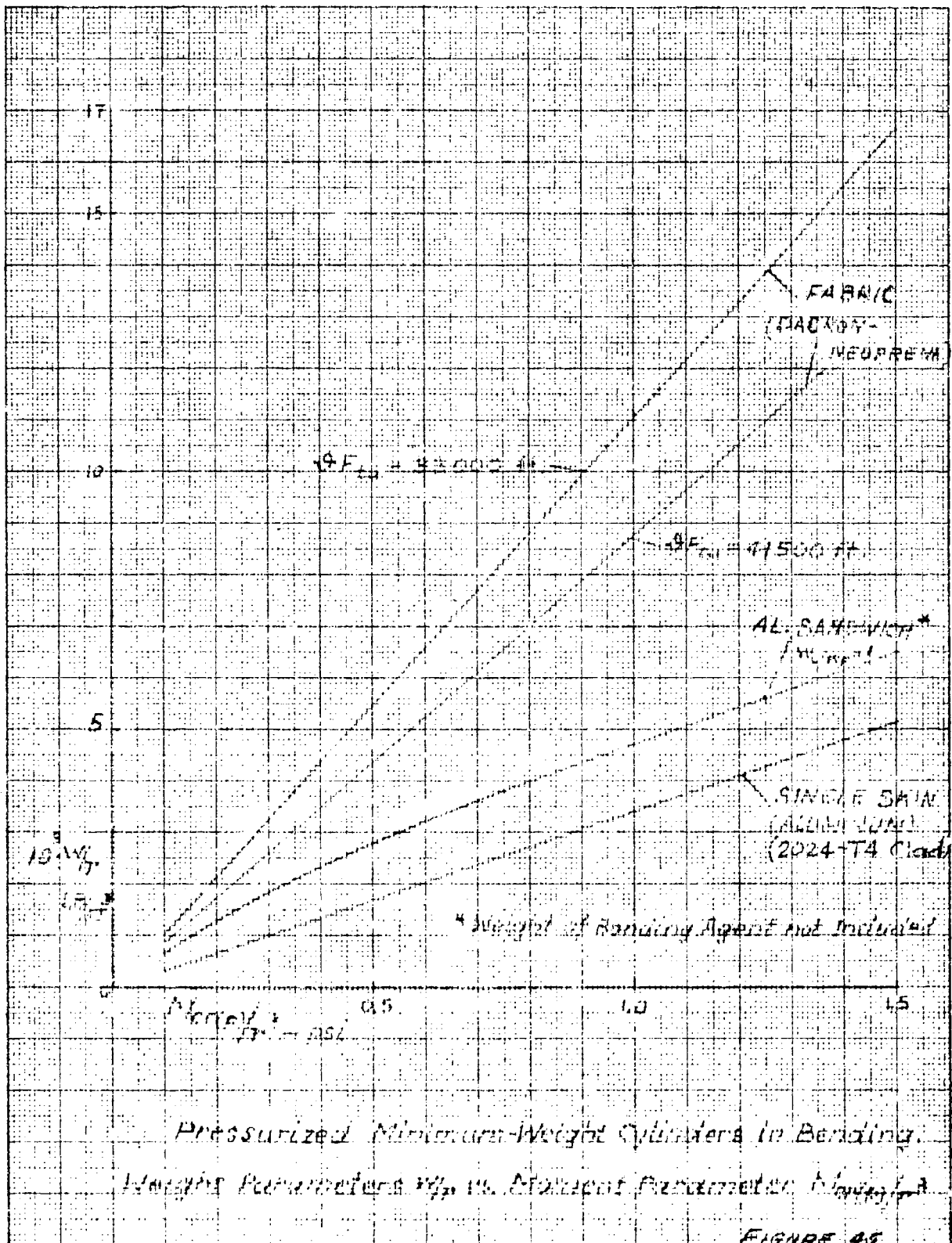
In fact, the slopes of the straight lines, representing fabric design and single-skin design, respectively, (Figure 45) are exactly in the same proportion.

This fact should not be construed to indicate an over-all superiority of either single-skin or sandwich design. It should be borne in mind that airships of either of these two classes fall under the category of "pressurized rigid airships" and require stiff transverse frames, properly spaced along the length of the ship, in order that form stability of the hull

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be insured and a loadpath for equilibrating static lift and suspended loads be provided. The single-skin design requires in addition stringers or some other type of longitudinal stiffeners for stability. These components increase the structural weight to a much greater extent than do the suspension systems which perform similar functions on non-rigid airships. It is primarily this point that makes it possible for the non-rigid airship to compete successfully - weightwise and otherwise - with the two other constructions, even though the weight of the fabric envelope proper turns out to be considerably higher than that of an aluminum envelope (single skin or sandwich).

Another aspect should be discussed here. So far, the analyses in the preceding section have dealt exclusively with the nearly cylindrical midsection of the airship. From there both hoop and longitudinal tensile stresses (in lb/in) usually decrease toward both bow and tail, though not necessarily at the same rate. Therefore, the bow and tail sections of metal-clad airships of moderate volume and airspeed will be penalized in structural weight, from those cross sections on, at which the sheet or face thickness has diminished to the minimum gage. In this respect, the fabrics of non-rigid airships offer considerably more latitude in the tailoring of strength and weight. This aspect, loses its importance as larger and faster ships are considered.

The influence upon the "effective" pressure of the various flight conditions does not lend itself to parametric treatment, but should be investigated, in each individual case, by a detail analysis. Some of the more important cases will be briefly discussed.

a. Straight and Level Flight in Static Equilibrium

The air flow produces positive pressures only on the foremost portion of the bow and on the sternmost portion of the tail; the remainder of the body is subjected to negative aerodynamic pressures. These, in effect, add to the pressure differential between the gas and air content of the ship and the ambient air and thus, affect the stress distribution in the structure, whatever design construction approach is selected.

The distribution of the aerodynamic pressure along the length of the airship is a function of the airspeed and of the characteristics of the envelope contour, primarily the fineness ratio, cylinder coefficient, and abscissa of the maximum diameter.

b. Horizontal Flight of a Heavy or Light Airship with an Angle of Attack

The pressure distribution follows the general law

$$\frac{P}{q} = A + B \cos \phi + C \cos(2\phi)$$

where the coefficients A, B, and C are functions of the aforementioned contour characteristics of the envelope, also of the angle of attack and of the abscissa, ϕ in any cross section is the angle between the vertical axis and the radius to the particular point on the envelope ($\phi = 0$ at the bottom, $\phi = \pi$ at the top).

It is observed that the component $q B \cos \phi$ is the only one that contributes to the dynamic lift of the airship. The total dynamic lift of the unfeathered ship is found to be

$$L_d = q \int_0^{2\pi} \int_0^L B r \cos^2 \phi d\phi dx$$

All three components of the pressure, however, affect the stress distribution in the hull structure. Their influence should be checked on a number of judiciously selected cross sections, particularly on high-speed ships flying with considerable static heaviness.

Similar considerations apply to the flight conditions: Stationary and Transient Turns, and Gusts.

c. Maximum Rate of Ascent

The climbing airship must release air from the ballonets and - upon reaching pressure height - gas through the gas valves. The maximum rate of ascent requires full opening of either valve type. This in turn necessitates an increase in pressure, over and above the pressure differential for which the valve is set to start opening.

This may happen simultaneously with, or as a direct consequence of, a gust that pushes the airship upward. It is therefore recommended that the design of the envelope, whether metal-clad or fabric, be for a limit pressure equal to the total pressure necessary to meet the gust condition plus the "valve-opening pressure". (the difference in the pressure required to start the valve to open and the pressure required to open it all the way).

SECTION VI - AERODYNAMICS

1. ZERO LIFT DRAG EQUATIONS

Four zero lift drag equations were established for the airship parametric study and were derived to allow for variations in the type of airship, (non-rigid, rigid, 3-lobe, and 5-lobe DYNASTATS), the effect of the envelope length and surface area (Reynolds number) and differences in the drag components of the airships (external car, buried car, etc.).

The major component of the zero lift drag equation is the drag attributed to the envelope and is a function of Reynolds number, which is based on the envelope length, the velocity of the airship through the air and the kinematic viscosity of air (ν). The non-rigid, rigid, 3-lobe and 5-lobe DYNASTAT envelope drag coefficients versus Reynolds number as derived as follows are plotted in Figure 46.

The variation of envelope drag coefficient with Reynolds number for the non-rigid airship was extracted from Reference 9, for a length to diameter ratio of 4.175 which is assumed to be typical of non-rigid designs. The line is based on an average of wind tunnel tests points on previous airship designs as tested at various Reynolds numbers and in various wind tunnels. The rigid airship envelope drag coefficient plotted on Figure 46 was extracted from Reference 7, which was a test of the U.S. "Akron" hull shape, length to diameter = 5.9, at various Reynolds numbers.

Only one wind tunnel test has been conducted on the DYNASTAT hull configuration, Reference 3. Therefore, the bare hull drag coefficient as measured in the tunnel at a Reynolds number of 1.1×10^7 was plotted on Figure 46 for the 3- and 5-lobe DYNASTAT hulls. It was then assumed due to the lack of extensive test data that the DYNASTAT bare hull drag coefficient would vary with the same slope as the non-rigid airship.

It should be noted that during previous limited studies on DYNASTAT, correlation of the drag coefficient with conventional hulls at varying Reynolds numbers was not accomplished and it was assumed that the DYNASTAT bare hull drag coefficient would be approximately the same as the non-rigid airships if the two types of hulls maintained equal surface area, (same friction drag). As may be seen from Figure 46 the

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EAST AVALI DATA INTERFERING VS REYNOLDS NUMBERS

NON-RISE $C_D = [0.45 \text{ RM}^{-1.5}] 6.40$

RISE $C_D = [0.30 \text{ RM}^{-1.5}] 7.01$

2-LORE $C_D = [0.70 \text{ RM}^{-1.5}] 5.92$

5-LORE $C_D = [0.11 \text{ RM}^{-1.5}] 6.55$

DYNASTATE
5-LORE TEST POINT
5-LORE TEST POINT

CONVENTIONS
NON-RISE (Fig. 53)

RISE (Fig. 53)

FIGURE 98

REYNOLDS NUMBERS

3 2 1 0 1 2 3 4 5 6 7 8 9

DYNASTAT drag coefficients are considerably higher than the conventional hull shapes. Further discussion of the difference in the DYNASTAT and conventional hull drag coefficients is presented on page 249.

The zero lift drag of the airships (drag at zero angle of attack, no dynamic lift) is expressed by the equation:

$$\text{Drag}_{Z. L.} = A_{D_T} q$$

where:

$$A_{D_T} = \text{total drag area, ft}^2 = C_D \psi^{2/3}$$

$$q = \text{dynamic pressure, lb/ft}^2 = (1/2)\rho v^2$$

$$\rho = \text{mass density of air, lb/sec}^2/\text{ft}^4$$

$$v = \text{velocity, ft/sec}$$

The total drag area is assumed to be composed of the following

$$A_{D_T} = A_{D_{\text{env}}} + A_{D_{\text{env access}}} + A_{D_{\text{fixed}}} + A_{D_{\text{car}}}$$

In order to parametrically describe the envelope drag areas the envelope drag coefficients as shown on Figure 46, (based on $\psi^{2/3}$) were mathematically expressed as follows so that they could be stated not only as a function of Reynolds number but also as a function of the surface area of the envelope (changing with number of lobes).

The envelope drag coefficient based on wetted surface area may be stated as a function of Reynolds number by the following expression:

$$C_{D_{\text{wetted area}}} = K_1 (R. N.)^m$$

The envelope drag coefficient based on $(\psi^{2/3})$ is related to the envelope drag coefficient based on wetted area (S_w) in the following way.

$$D_{\psi^{2/3}} = \text{drag}_{\text{wetted area}}$$

$$C_{D_{\psi^{2/3}}} \times q \psi^{2/3} = C_{D_{W. A.}} \times q \times S_w$$

And S_w is related to $\Psi^{2/3}$ by a constant K_2 for each configuration. (For DYNASTAT configurations see Figure 47) or

$$S_w = K_2 \Psi^{2/3}$$

$$C_{D_V^{2/3}} \times q \times \Psi^{2/3} = C_{D_{W.A.}} \times q \times K_2 \Psi^{2/3}$$

$$C_{D_V^{2/3}} = K_2 C_{D_{W.A.}}$$

or

$$C_{D_V^{2/3}} = K_1 (R.N.)^m K_2$$

Multiplying the envelope drag coefficient based on $\Psi^{2/3}$ by $\Psi^{2/3}$ gives the drag area in ft^2 . ($A_{D_{env}} = C_{D_V^{2/3}} \Psi^{2/3}$)

The Reynolds number is equal to:

$$R.N. = \frac{v \times L}{\nu}$$

where:

v = velocity = ft/sec = 1.689 knots

L = airship envelope length = ft

ν = kinematic viscosity of air

The length of the envelope may also be expressed as a function of $\Psi^{1/3}$ or $L = K_3 \Psi^{1/3}$

Therefore the drag area of the envelope may be expressed as:

$$A_{D_{env}} = K_1 \left[\frac{1.689 v K_3 \Psi^{1/3}}{\nu} \right]^m K_2 \Psi^{2/3}$$

Based on correlation of the envelope dimensions and corresponding volumes and slopes of the lines on Figure 46 the following K and m factors are assigned to the equation.

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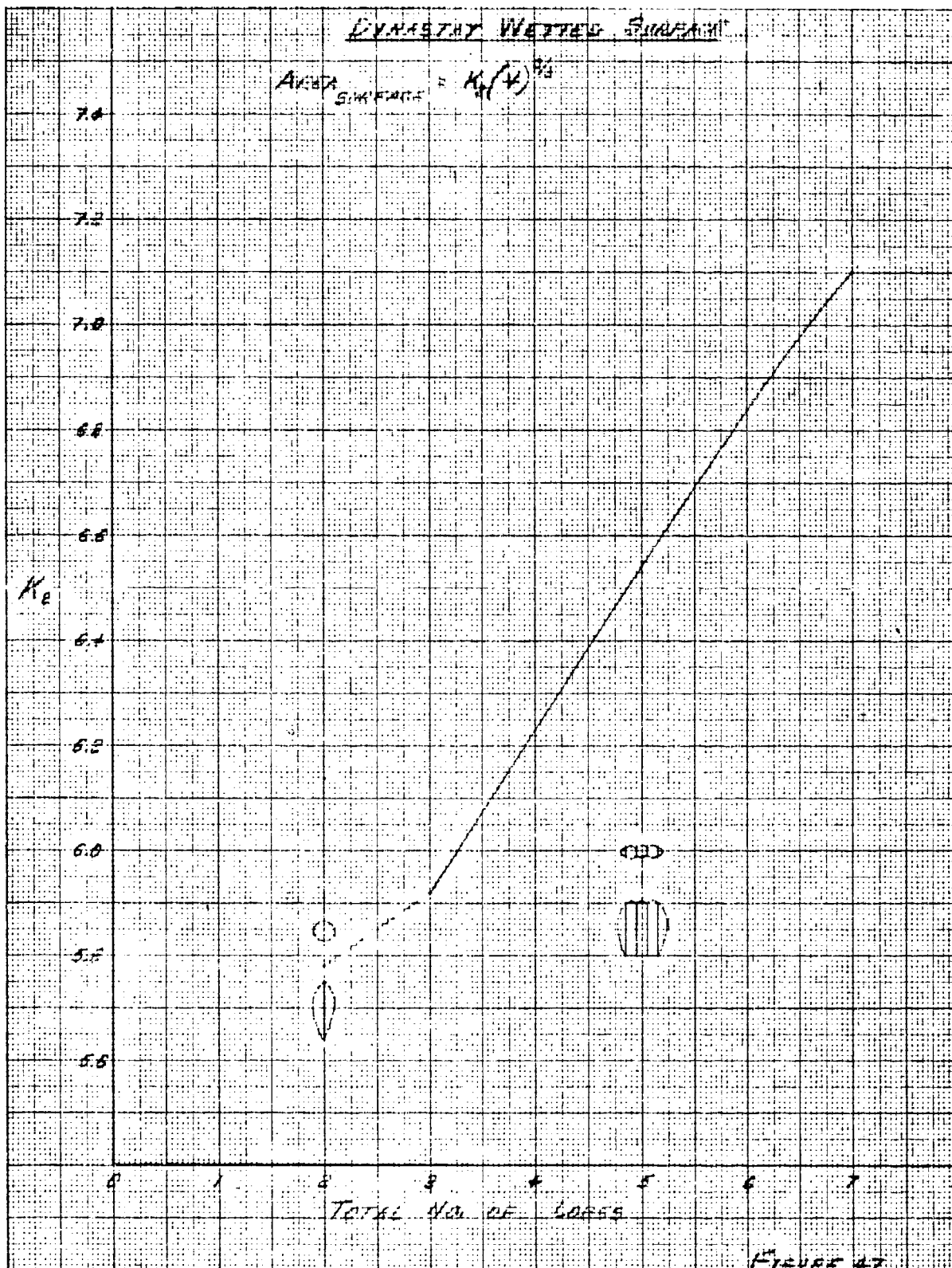


FIGURE 47

Hull type	K_1	K_2	K_3	m
Non-rigid	.045	6.40	3.25	-.154
Rigid	.030	7.01	3.85	-.145
3-lobe	.072	5.92	3.28	-.154
5-lobe	.071	6.55	2.51	-.154

Table VI-1 compares the component drag areas assigned to the four types of airships and is based on historical data and data contained in Reference 10.

Substituting the K and m factors and the drag areas of Table VI-1 into the drag equation the following parametric equations are derived.

Non-rigid airship

$$\text{Drag}_{Z.L.} = q \left[(.289) \left(\frac{V_K \Psi^{1/3}}{V} \right)^{-.154} (\Psi^{2/3}) + 19.7 + .0000003\Psi - \frac{50}{(.00001\Psi^2)} \right]$$

Rigid airship

$$\text{Drag}_{Z.L.} = q \left[(.213) \left(\frac{V_K \Psi^{1/3}}{V} \right)^{-.145} (\Psi^{2/3}) + 15 \right]$$

3-lobe

$$\text{Drag}_{Z.L.} = q \left[(.427) \left(\frac{V_K \Psi^{1/3}}{V} \right)^{-.154} (\Psi^{2/3}) + 17.5 \right]$$

5-lobe

$$\text{Drag}_{Z.L.} = q \left[(.483) \left(\frac{V_K \Psi^{1/3}}{V} \right)^{-.154} (\Psi^{2/3}) + 17.5 \right]$$

2. INDUCED DRAG DUE TO LIFT

The induced drag due to dynamic lift of the airship is expressed as follows:

TABLE VI-1

DRAG AREA COMPARISON

$A_{D_{total}} = A_{D_{env}} + A_{D_{env access}} + A_{D_{fixed}} + A_{D_{car}}$				
Non-rigid	Rigid	3-Lobe	5-Lobe	
$A_{D_{env}} =$ $\left[.045 \text{ R.N.} \cdot .154 \right] \frac{2}{3}$ $6.4\psi^3$	$\left[.03 \text{ R.N.} \cdot .145 \right] \frac{2}{3}$ $7.01\psi^3$	$\left[.072 \text{ R.N.} \cdot .154 \right] \frac{2}{3}$ $5.92\psi^3$	$\left[.071 \text{ R.N.} \cdot .154 \right] \frac{2}{3}$ $6.55\psi^3$	
$A_{D_{env access}} =$ $\% \text{ Env } A_D$ Nose mooring and battens 2.0 Tail surfaces 21.0 4 wire brace cables 4.0 Handling lines 1.3 Misc & Interfer 2.2 Total = 30.5%	$A_{D_{env access}} =$ $\% \text{ Env } A_D$ Hull access 5.0 Tail surfaces 24.0 Tail surface brace cables 2.0 Handling lines 0.0 Misc & Interfer 2.0 Total = 33.0%	$A_{D_{env access}} =$ $\% \text{ Env } A_D$ Tail surfaces 24.0 4 wire brace cables 4.0 Misc & Interfer 2.5 Total = 30.5%	$A_{D_{env access}} =$ $\% \text{ Env } A_D$ Tail surfaces 24.0 4 wire brace cables 4.0 Misc & Interfer 2.5 Total = 30.5%	
$A_{D_{fixed}} = Ft^2$ Running lights and env patches 1.5 Tail surface access, light, rudder horn 1.0 Total = 2.5 ft ²	$A_{D_{fixed}} = Ft^2$	$A_{D_{fixed}} = Ft^2$ Running lights and env patches 1.5 Tail surface access, light, rudder horn 1.0 Total = 2.5 ft ²	$A_{D_{fixed}} = Ft^2$ Running lights and env patches 1.5 Tail surface access, light, rudder horn 1.0 Total = 2.5 ft ²	
$A_{D_{car}} =$ $17.2 + .0000003\psi - \frac{50}{(00001\psi)^2}$	$A_{D_{car}} = 15 \text{ ft}^2$	$A_{D_{car}} = 15 \text{ ft}^2$	$A_{D_{car}} = 15 \text{ ft}^2$	

$$D_i = C_{D_i} \times q \times V^{2/3}$$

where

$$C_{D_i} = K_4 C_L^2$$

C_L = lift coefficient required for given heaviness
or dynamic lift

Based on wind tunnel tests of the various airships at several angles of attack (lift coefficients) the following K_4 factors are found:

Airship	K_4
Non-rigid	.9
Rigid	.9
3-lobe	.42
5-lobe	.46

3. TOTAL AIRSHIP DRAG

The total airship drag is equal to the summation of the zero lift drag and the induced drag.

$$\text{Drag}_{\text{total}} = \text{Drag}_{\text{zero lift}} + \text{Drag}_{\text{induced}}$$

4. POSSIBLE DYNASTAT REDUCTION IN ZERO-LIFT DRAG

The zero lift drag coefficient of the conventional airships, 3-lobe and 5-lobe DYNASTATS are shown in Figure 46 plotted against Reynold's number. It can be seen that the drag coefficients of the DYNASTATS are considerably above those of the airship. This is probably caused by flow separation introducing base drag at the small rounded knobs behind each lobe incorporated by the designers to close the pressure cell of non-rigid designs.

The first indication that this might be the cause was noted in the analysis of the wind tunnel tests, References (3) and (4). Here, it was observed that the total drag was reduced when the tail was added to the tailless body. It appears that this tail performs a flow-straightening service which reduces the separation and the drag of the body more than the increased drag

of the tail itself, resulting in a net drag decrease. An idea of the magnitude of this effect is shown in Reference (6), Figure 40, p 3-21. This shows that the drag of an airfoil was doubled by cutting off 2 1/2 percent of the trailing edge.

It is believed that this is sufficient evidence to conclude that the drag of the DYNASTAT could be reduced by a combination of alterations and wind-tunnel tests, but not by a factor of two. There is, however, enough evidence available to justify a prediction of what might be accomplished if such a test program were successfully accomplished.

Drag data is available reduced to coefficient form based on three different areas: plan form; frontal; and wetted surface area. By comparing the DYNASTAT drag coefficient separately on each basis, and then examining the results an educated estimate can be made. The results of the 5-lobe DYNASTAT at a Reynold's number of 10^7 were chosen for direct comparison of the method.

Based on wing area, the drag coefficient of the DYNASTAT from the tests is $C_d = .015$. Reference (6), Figure 2, page 6-2, shows strut drag of the same thickness (22.8 percent) to be a $C_d = .0075$. The strut drag is two-dimensional so that the ends are not included as is the tail. It is postulated that the drag coefficient might be reduced to $C_d = .012$.

Based on frontal area the DYNASTAT drag coefficient becomes $C_d = .058$. Reference (6), Figure 25, page 6-19, shows the drag coefficient of bodies-of-revolution based on fineness ratio. If the DYNASTAT were reduced to a circular streamline body having a diameter of the equivalent frontal area, its L/D becomes 2.83, and the equivalent streamline body has a drag coefficient of $C_d = .04$. Since the DYNASTAT has less thickness but does have a tail, the trends are in opposition. Accordingly it is suggested that the DYNASTAT drag might have a minimum value $C_d = .045$.

Based on wetted area the DYNASTAT drag coefficient becomes $C_d = .006$. Reference (6), Figure 5, page 2-6, shows the turbulent skin friction of a flat plate $C_d = .003$. Reference (6), Figure 22, page 6-16, shows the drag of rotationally symmetrical streamline bodies. If the equivalent body has

the same perimeter at the maximum section, the $L/D = 2.5$ and the drag coefficient $C_d = .006$. If minimum thickness is used $L/D = 4.4$ and the drag coefficient $C_d = .004$. It is postulated that the lowest drag attainable might be $C_d = .0045$.

If these estimates of the lowest drag attainable are converted to drag coefficients based on $V^{2/3}$, then the results may be compared directly:

from wing area, $C_d = .0312$

from frontal area, $C_d = .0302$

from wetted area, $C_d = .0294$

This shows that the drag coefficient might be reduced from the measured $C_d = .039$ to a value of $C_d = .030$ if sufficient wind-tunnel work were done.

Since this low drag is postulated on unfounded assumptions, the calculations of this study are based on the actual values tested. The effect of this drag reduction is made for one 3-lobe ship to see how important a parameter this value is. For the tables of the "IDEALIZED DYNASTAT" the factor of .427 used in the 3-lobe DYNASTAT drag equation given earlier, was reduced to .350. This reduction is in line with the .030/.039 implied above for the 5-lobe DYNASTAT.

5. PROPULSIVE THRUST EQUATIONS

A brief parametric study was conducted to determine the propeller efficiencies that could be expected for given flight velocity, propeller diameter and engine brake horsepower-propeller RPM combinations in order that basic thrust equations could be written.

Propulsive thrust is calculated from the following equation:

$$T = \frac{BHP \times 550 \times \eta_p}{1.689 \times V_K}$$

where η_p is a function of

$$C_p = \frac{550 \text{ BHP}}{n^3 D^5}, \text{ power coefficient}$$

and

$$v/nD = \frac{1.689 V_K}{n \times G.R. \times D}$$

where:

BHP = brake horsepower to propeller shaft

η_p = propeller efficiency

V_K = velocity in knots

n = propeller revolutions per second

D = propeller diameter in feet

G.R. = engine to propeller gear ratio

The propeller efficiencies were read from a "typical" propeller efficiency map for the calculated C_p 's and v/nD 's which was a map for a 2 bladed, activity factor of 90 propeller (Reference 8). This map was considered to give representative propeller efficiencies and for a specific design activity factor and number of blades would be considered to give maximum efficiencies for the velocity spectrum.

Three engines were chosen to be typical of the brake horsepower - RPM range of the study.

1. Wright Aeronautical 981TC18EA1
Take-off power = 3700 BHP at 2900 RPM
NRP = 2920 BHP at 2600 RPM
Gear ratio = .4375 to 1
2. Wright Aeronautical 918C9HE1 (used in the ZPG-3W airship)
Take-off power = 1525 BHP at 2800 RPM
NRP = 1275 BHP at 2500 RPM
Gear ratio = .350 to 1
3. General Motors, Allison Div. (gas turbine engine)
NRP at S. L. = 4410 ESHP
Shaft RPM = 1021, rotor RPM 13,820
Gear ratio = 1021/13,820 = .074

The following matrix describes the combinations of propeller diameter, velocities, engines and gear ratios that were analyzed.

Propeller diameter	V_K (knots)	Engine designation		
		981TC18EA1	918C9HE1	T56-A-18
		Gear ratio		
15 ft	210	.70	.25	.05
20 ft	140	.30	.30	.06
25 ft	70	.4375*	.35*	.074*
30 ft		.50	.40	.08
		.60	.45	.09

*Standard gear ratio

Table VI-2 tabulates the η_{\max} and 2nd η_{\max} that was developed from the matrix and propeller efficiency map for the normal rated power of the engines.

Based on the propeller efficiencies shown on Table VI-2 and past airship design analyses it was considered that with proper engine-propeller gear ratio's - propeller diameters the following efficiencies would be attainable for any specific airship design.

V_K	η
210	.85
140	.85
70	.70
30	.70

(Note the 30-knot condition was not analyzed but from previous airship designs $\eta = .70$ is achievable)

Substituting the η 's into the thrust equation and conservatively assuming that η varies linearly from 70 knots to 140 knots the following thrust equation is derived.

$$\text{Thrust} = K \text{ BHP} / V_K$$

V_K	K
30	228
70	228

(continued under Table VI-2)

TABLE VI-2

EVALUATION OF PROPELLER EFFICIENCY FOR VARIOUS PROPELLER DIAMETERS, ENGINES AND ENGINE PROPELLER GEAR RATIOS						
Engine no.	V_K	Prop dia	G. R.	η_{\max}	$2^{\text{nd}} \eta_{\max}$	N. R. P. (BHP at RPM)
981TC18EA1	210	25'	.20	.869		(2920 BHP at 2600 RPM) (Standard G. R. = .4375)
	210	30'	.20		.863	
	140	30'	.20	.869		
	140	25'	.30		.844	
	70	30'	.20	.710		
	70	25'	.30		.670	
756-A-18	210	25'	.06	.870		(4410 BHP at 13,820 RPM) (Standard G. R. = .074)
	210	20'	.09		.870	
	140	30'	.05	.830		
	140	25'	.06		.830	
	70	30'	.05	.650		
	70	25'	.06		.620	
918C8HE1	210	15'	.45	.878		(1275 BHP at 2500 RPM) (Standard G. R. = .35)
	210	20'	.25		.875	
	140	20'	.30	.867		
	140	20'	.35		.859	
	70	25'	.25	.749		
	70	20'	.35		.715	

V_K	K
80	235
90	242
100	249
110	256
120	263
130	270
140	277
210	277

It is also assumed that in a parametric design condition where several engines are used to attain V_{\max} and then some of the engines are stopped that a compensating increase in the propeller efficiency of the remaining engines could offset the increase of the nacelle drag of the stopped and feathered propellers.

6. STABILITY

Wind tunnel test of airship models with and without tails have shown that the horizontal tail surfaces carry a large part of the dynamic lift in flight. Elevator deflection also provides large changes in lift and all exact calculations must be made with the control surfaces in trim.

This points up the importance of making early tests of the DYNASTAT to determine the rotary derivatives and to fix the tail size. The resulting over-all performance can change considerably if the proper tail is not included.

The DYNASTAT is a vehicle part way between an airship, which is principally supported by buoyancy, and an airplane in which buoyancy is neglectably small. This poses a problem in determining the tail size of the DYNASTAT because the basic stability criteria are different for the two vehicles.

Airplanes with varying degrees of stability and instability have been built and flown successfully. In general, airplanes that are statically unstable are not as comfortable to fly as airplanes which have both stick-fixed and stick-free stability. Accordingly this stability requirement has been incorporated into all recent airplane specifications.

By the same criteria airships which were known to fly quite well should have been seriously unstable. It was at this point that the airship pioneers developed the dynamic stability criteria now used for airship design, involving the use of rotary stability derivatives. Because buoyant lift dominates in the DYNASTAT it is assumed at this time that the airship stability criteria will provide satisfactory flight characteristics even though the static moment curves may show an unstable slope.

The several types of stability are defined as follows:

Rectilinear inherent dynamic stability of an airship is that quality which causes the angular velocity and attitude resulting from an initial disturbance of the motion of the ship to decrease with time without benefit of control adjustment and with relatively small consequent course deviation.

Curvilinear inherent dynamic stability is defined as the quality which causes the flight path resulting from an initial disturbance to approach asymptotically a circle of definite radius. The following combinations of the stability conditions are possible:

- (a) Rectilinear dynamic stability, curvilinear dynamic stability
- (b) Rectilinear dynamic instability, curvilinear dynamic stability
- (c) Rectilinear dynamic instability, curvilinear dynamic instability

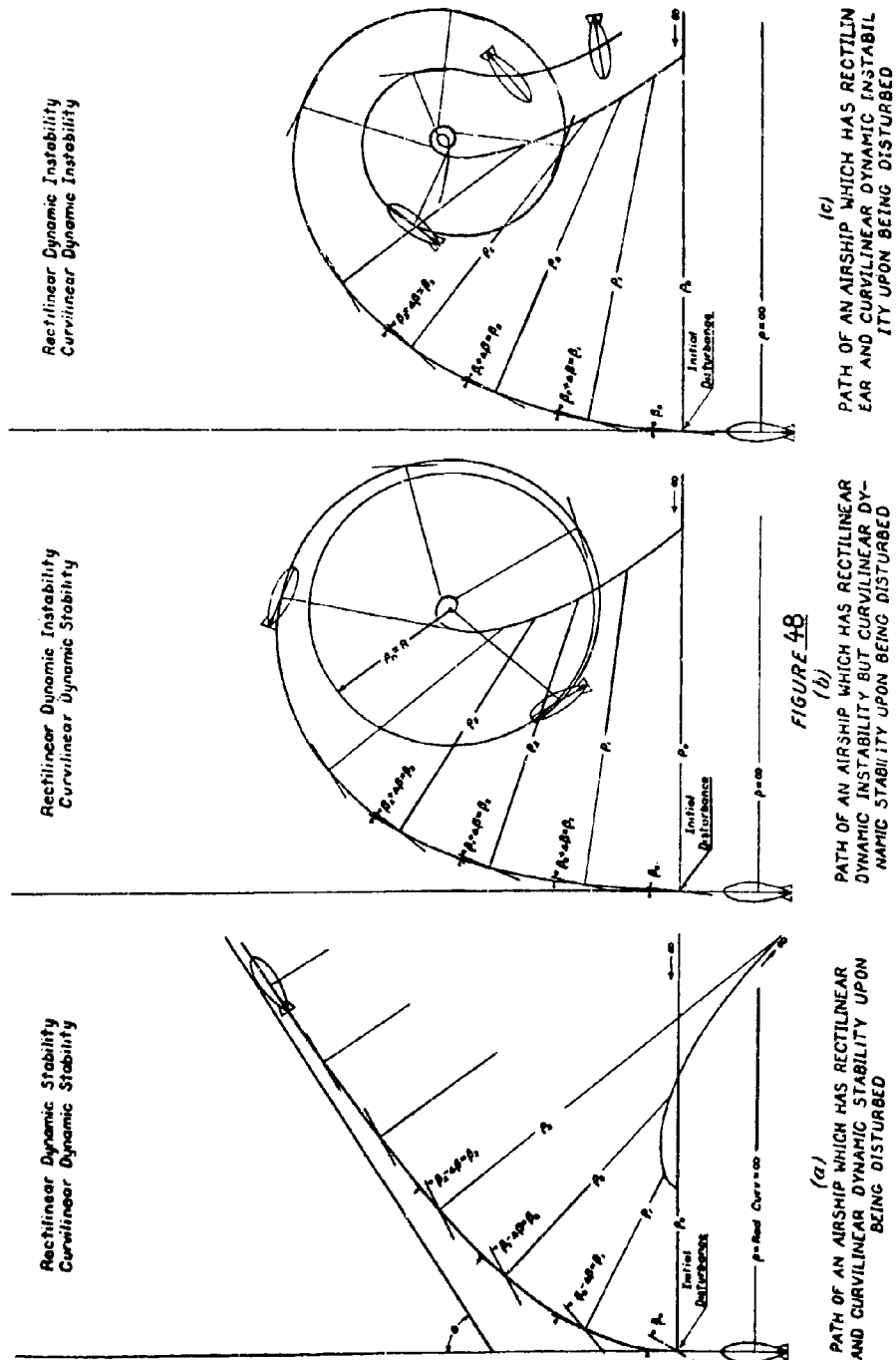
These types of stability are shown in Figure 48. In the first case, (a) after a disturbance the airship straightens out on a new heading. One or more oscillations may occur about the new heading but it would be desirable for this to be damped out.

In the second case, (b) the airship seeks the circumference of a definite circle and continues to fly in a constant-radius turn. The angle of yaw produces a side force which exactly balances centrifugal force.

In the third case, (c) the airship spirals inward with decreasing radius and increasing yaw until it tumbles due to flow breakdown.

Case (a) is typical of a stable airplane whereas case (b) is typical of a stable airship.

A mathematical determination of the concept of dynamic stability can be evaluated from the differential equations of motion based on the theory of small oscillation. For a condition of dynamic stability to exist the real roots are indications of non-oscillatory convergent modes. In general, the more negative the root, the shorter the time required for an arbitrary perturbation to damp to a fraction of its initial amplitude and the better the handling qualities of the airship in equilibrium flight. If the real roots are positive the motion of the airship is dynamically unstable, which is



undesirable because it is characterized by a succession of tight curves and application of relatively large rudder deflections to maintain course.

The evaluation of inherent dynamic stability without the assistance of auto-pilots or servos is a relatively simple problem when considering small disturbances from equilibrium flight, once the stability derivatives are known.

For the airship to be stable by this criteria, the following expression must be negative:

$$I = m' + \frac{n'm'' - m'n''}{2k_x} \leq 0 \text{ (preferably about } -0.5)$$

m' = slope of moment curve C_{m_α}

n' = slope of lift curve C_{l_α}

m'' = rotary moment derivatives $C_{m_q} \times V/\psi^{1/3}$

n'' = rotary lift derivative $C_{l_q} \times V/(\psi)^{1/3}$

k_x = longitudinal virtual mass coefficient ($1 + k_1$)

k_1 = longitudinal additional mass coefficient (varies from .09 to .13 for airships)

$C_l = L/\psi^{2/3} (1/2 \rho V^2)$

$C_m = M/\psi (1/2 \rho V^2)$

α = angle of attack - radians

q = angular velocity - radians/second

The more negative the numbers, the more stable the airship. Airships have been built with this number varying between -.182 and -.580. One of the more successful is the ZPN-1 which had a stability index of -.503 longitudinally and -.526 laterally.

A search for rotary derivative data on shapes similar to the DYNASTAT was made so that the tail size could be evaluated. The only data that could be located is a subsonic test of a reentry body reported in Reference (34). These data were corrected for C. G. location and applied to the stability criteria index. The body with tails had an index of -8.2 and without the tail it was -9.1.

This indicates that the DYNASTAT is strongly stable and the horizontal tail is required mainly for control and not for stability. Accordingly the aerodynamic data with tails on is considered adequate for these analyses.

An attempt was made to estimate the radius of the equilibrium circle of turn or the centrifugal force developed in the "hands-off" control neutral turn. However, no way was found of calculating this value. The radius of turn is usually measured during airship trials.

7. TAKE-OFF ANALYSIS

The accurate prediction of the running take-off distance is exceedingly difficult due to the various control manipulation techniques that pilots employ during the ground run and transition phase. Also, extensive flight test data needed to develop empirical correlation factors between theoretical prediction methods and flight test data are lacking. Based on the limited number of recorded test data points on airships of varying volumes, it is found that the actual measured take-off distances are normally less than what is predicted.

As an example of predicted versus measured take-off distance the following data is taken from Reference 9.

	<u>Predicted</u>	<u>Measured</u>
Ground run distance	1260 ft	587 ft
Total distance to clear 50 ft obstacle	2050 ft	1468 ft
Airship heaviness = 10,465 lb \approx 10% of gross weight		
Wind = 4.5 knots		

Therefore the measured ground run distance was 46.6 percent of predicted and the total measured over an obstacle was 71.5 percent of predicted. In all the recorded cases the measured take-off distances were less than predicted.

The following statement also appears in an unpublished Lighter Than Air Aerodynamic Handbook (Reference 5).

"Corresponding studies made on other non-rigid airships indicate that the ground run required at maximum take-off heaviness and the transition over a 50 ft obstacle are both in the order of 2 1/2 airship lengths at zero headwind and optimum control manipulation."

Using the ZPG-3W airship length of 406.7 ft, Reference (9), the following comparison of the 2 1/2 factor, predicted and flight test distances may be made.

	<u>2 1/2 length</u>		<u>Pred.</u>	<u>Meas.</u>
Ground run distance	1017 ft	1260 ft		587 ft
Total distance to clear 50 ft obstacle	2034 ft	2050 ft		1468 ft

As may be seen the 2 1/2 airship lengths also over-predicts the take-off distances. In the case of the ZPG-3W airship, the measured distances in terms of the airship length would be:

$$\text{Ground run} = \frac{587}{406.7} = 1.448$$

$$\text{Total distance} = \frac{1468}{406.7} = 3.60$$

Therefore it is suggested that as a first approximation of take-off distance for the parametric study the factor for the ground run distance would be 1.5 times the airship length and the transition distance 2.1 times the airship length.

Ground run distance

The following discussion will present the derivation of the ground run equation. As a base the derivation for the ZPG-3W airship, Reference 9, will be used and modifications will be made for parametric use.

The ground run distance may be expressed by the following integral:

$$S = \int_0^{v_{to} - v_w} v_g dt = \int_0^{v_{to} - v_w} v_g \frac{dv_g}{\left(\frac{dv_g}{dt}\right)} = \int_0^{v_{to} - v_w} \frac{d(vg)^2}{2\left(\frac{dv_g}{dt}\right)}$$

The variation of v_g^2 with $1/2 (dv_g/dt)$ is approximately linear.

$$S = \frac{(v_{to} - v_w)^2}{2 \left(\frac{dv_g}{dt}\right)}$$

where (dv_g/dt) is the acceleration and,

$$v_g^2 = 1/2 (v_{to} - v_w)^2$$

$$v_g = .707 (v_{to} - v_w)$$

$$v = v_g + v_w = .707 v_{to} - .707 v_w + v_w$$

$$v = .707 v_{to} + .293 v_w$$

The airship accelerates horizontally under the action of these forces (thrust drag, wheel friction), therefore

$$T - D - W.F. = m_L \left(\frac{dv_g}{dt}\right)$$

or,

$$\left(\frac{dv_g}{dt}\right) = \frac{T - D - W.F.}{m_L}$$

The ZPG - 3 Warship at take-off power (1525 BHP and 2800 RPM) and allowing 45 BHP/ENG for electrical load the variation of total propeller thrust velocity is approximated by:

$$T = 17,300 - 125.6v + .414v^2 \text{ (2 engines)}$$

The thrust equation tabulates as follows:

V_K	Thrust/engine
0	8650
10	7625
20	6725
30	6000
40	5400
50	4850
60	4410
70	4110
80	3950

As an approximation a straight line may be drawn to replace the curve going through the following two points.

V_K	Thrust/engine
0	8200
100	2150

The equation of the straight line is:

$$T = 8200 - 61 V_K$$

The equation for thrust is:

$$T = \frac{\text{BHP} \times 550 \times \eta_p}{v}$$

Then it can be assumed that the thrust curve varies with the ratio of the $\text{BHP}_{\text{NEW}}/\text{BHP}_{\text{ZPG-3W}}$ (assuming equal propeller efficiency) or for a given engine or engines

$$T = \left(\frac{\text{BHP}/\text{ENG}}{1525} \right) (\text{no. engines})(8200 - 61 V_K)$$

The drag area of the ZPG-3W airship is estimated to be 343 ft^2 at 75 knots for the normal configuration. Allowing for an average pitch angle of 3 deg and for other incremental drag increases during the take-off a drag area of 381 ft^2 can be assumed for take-off. The equation for drag is as follows:

$$D = \frac{A_D v^2}{2} = .453 v^2$$

The increase in drag area assumed for the ZPG-3W is $381/348 = 1.095$. Therefore the drag expression for the parametric analysis will be increased by 1.095 and the induced drag for ground run will be zero.

The following drag equations are for the parametric study of drag during take-off.

Non-rigid airship

$$D = 1.095 q \left[(.289) \left(\frac{V_K v^{1/3}}{v} \right)^{-.154} (v^{2/3}) + 19.7 + .0000003 v - \frac{50}{(.00001 v)^2} \right]$$

Rigid airship

$$D = 1.095q \left[(.213) \left(\frac{V_K V^{1/3}}{\nu} \right)^{-.145} (V^{2/3}) + 15 \right]$$

3-lobe DYNASTAT

$$D = 1.095q \left[(.427) \left(\frac{V_K V^{1/3}}{\nu} \right)^{-.154} (V^{2/3}) + 17.5 \right]$$

5-lobe DYNASTAT

$$D = 1.095q \left[(.483) \left(\frac{V_K V^{1/3}}{\nu} \right)^{-.154} (V^{2/3}) + 17.5 \right]$$

Based on Reference 9 a friction coefficient ($\mu = .04$) is assumed for the wheel friction on short grass (sod runway). Assuming that the wheel load is based on the average static heaviness during the take-off run the equation of wheel friction is as follows:

$$W.F. = .04 \left(\frac{H}{2} \right) = .02 H$$

where

$$H = \left(1 - \frac{L_s}{W_o} \right) W_o$$

The mass to be accelerated is considered to be the sum of the physical mass of the airship, the longitudinal additional mass, and the heaviness. The longitudinal mass including viscosity, is assumed to be 9 percent of the mass of displaced air, the physical mass is assumed equal to the mass of the displaced air. This,

$$m_L = 1.09 \rho V + \frac{H}{32.2}$$

By substitution the acceleration for the ZPG - 3W airship would be:

$$\frac{dv_g}{dt} = \frac{17,300 - .039(.707v_{to} + .293v_w)^2 - 125.6(.707v_{to} + .293v_w) - .02H}{3920 + \frac{H}{32.2}}$$

For the parametric analysis the following equations for acceleration would be used.

Non-rigid

$$\frac{dv_g}{dt} = \frac{(\frac{BHP}{ENG})(Ne)(8200 - 61V_K) - D - .02H}{1.09 \rho \Psi + \frac{H}{32.2}}$$

Rigid

$$\frac{dv_g}{dt} = \frac{(\frac{BHP}{ENG})(Ne)(8200 - 61V_K) - D - .02H}{1.09 \Psi + \frac{H}{32.2}}$$

3-lobe DYNASTAT

$$\frac{dv_g}{dt} = \frac{(\frac{BHP}{ENG})(Ne)(8200 - 61V_K) - D - .02H}{1.09 \Psi + \frac{H}{32.2}}$$

5-lobe DYNASTAT

$$\frac{dv_g}{dt} = \frac{(\frac{BHP}{ENG})(Ne)(8200 - 61V_K) - D - .02H}{1.09 \Psi + \frac{H}{32.2}}$$

The take-off velocity is the velocity at which the airship will leave the runway; i. e. the point at which the dynamic lifting force acting on the airship exceeds the heaviness. The lifting force is a function of the air density, the velocity of the airship through the air, the volume of the airship and the lift coefficient. From consideration of tail clearance, a $C_L = .10$ at $\alpha = 6$ deg is used to calculate the take-off velocity. The lift can be written as:

$$L = C_L \rho/2 v^2 \Psi^{2/3}$$

The constant terms of the equation are:

$$\rho/2 = \frac{.002378}{2} = .001189 \text{ at sea level}$$

$$\Psi^{2/3} = 13,200 \text{ ft}^2 \text{ (ZPG-3 Wairship)}$$

The airship is on the verge of leaving the runway when the lift equals the heaviness. Rewriting the lift equation as follows:

$$L = H = C_L \rho/2 v^2 \Psi^{2/3}$$

Then

$$v_{to} = \sqrt{\frac{H}{.10 \times 001189 \times 13,200}} = \sqrt{\frac{H}{1.57}}$$

The following lift coefficients occur at $\alpha = 6$ deg for the parametric airship types.

Configuration	C_L
Non-rigid	.08
Rigid	.085
3-lobe	.110
5-lobe	.230

The take-off velocities for the parametric airships will then be:

Non-rigid

$$v_{to} = \sqrt{\frac{H}{.08 \times \rho/2 \times \Psi^{2/3}}} = \sqrt{\frac{H}{.04 \rho \Psi^{2/3}}}$$

Rigid

$$v_{to} = \sqrt{\frac{H}{.085 \times \rho/2 \times \Psi^{2/3}}} = \sqrt{\frac{H}{.0425 \rho \Psi^{2/3}}}$$

3-lobe

$$v_{to} = \sqrt{\frac{H}{.110 \times \rho/2 \times \Psi^{2/3}}} = \sqrt{\frac{H}{.055 \rho \Psi^{2/3}}}$$

5-lobe

$$v_{to} = \sqrt{\frac{H}{.230 \times \rho/2 \times \Psi^{2/3}}} = \sqrt{\frac{H}{.165 \rho \Psi^{2/3}}}$$

By substitution the final parametric equations for ground run become :

Non-rigid

$$S = \frac{\left(\sqrt{\frac{H}{.04\rho\psi^{2/3}}} - v_w \right)^2 \left(1.09\rho\psi + \frac{H}{32.2} \right)}{2 \left[\left(\frac{\text{BHP/ENG}}{1525} \right) (N_e)(8200 - 61V_K) - D - .02H \right]}$$

Rigid

$$S = \frac{\left(\sqrt{\frac{H}{.045\rho\psi^{2/3}}} - v_w \right)^2 \left(1.09\rho\psi + \frac{H}{32.2} \right)}{2 \left[\left(\frac{\text{BHP/ENG}}{1525} \right) (N_e)(8200 - 61V_K) - D - .02H \right]}$$

3-lobe

$$S = \frac{\left(\sqrt{\frac{H}{.055\rho\psi^{2/3}}} - v_w \right)^2 \left(1.09\rho\psi + \frac{H}{32.2} \right)}{2 \left[\left(\frac{\text{BHP/ENG}}{1525} \right) (N_e)(8200 - 61V_K) - D - .02H \right]}$$

5-lobe

$$S = \frac{\left(\sqrt{\frac{H}{.165\rho\psi^{2/3}}} - v_w \right)^2 \left(1.09\rho\psi + \frac{H}{32.2} \right)}{2 \left[\left(\frac{\text{BHP/ENG}}{1525} \right) (N_e)(8200 - 61V_K) - D - .02H \right]}$$

Where:

H = heaviness

ρ = mass density of air = .002378, S. L., std. day

ψ = airship volume, ft³

v_w = wind velocity, ft/sec

BHP/ENG = brake horsepower/engine, (take-off power)

N_e = number of engines

V_K = airspeed, knots

ν = kinematic viscosity = 000157, S. L., std day

v = airspeed - ft/sec

D = Drag, Equations Page 262, 263

S = Distance, ft

8. TRANSITION DISTANCE

The transition distance required to clear a 50 ft obstacle is dependent on such factors as elevator deflection, heaviness of the airship and headwind. The transition distance required to clear a 50 ft obstacle is affected by the three factors in the following manner. increasing the heaviness while keeping all other variables constant results in an increase in the distance required to clear the obstacle; an increase in the headwind velocity while the other variables are constant reduces the distance required to clear the obstacle; and elevator deflection may result in a greater or shorter distance depending upon the manner in which the controls are utilized.

Analysis of the transition phase requires that the motion of the airship be described by writing the three degree of freedom equations. Because of the complexity of the equation and the limited time of the parametric study program no attempt has been made to parametrically express the transition phase of the take-off.

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CONVENTIONAL AIRCRAFT DESIGN

VTOL CAPABILITY

$\Delta L/W_0 = 0.7$

$\Delta L/W_0 = 0.6$

$\Delta L/W_0 = 0.5$ (ADJUSTED)
 DATA

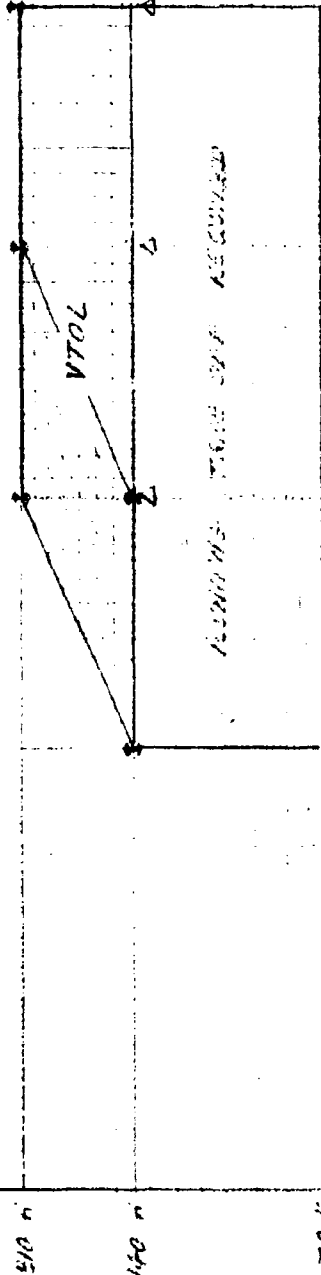
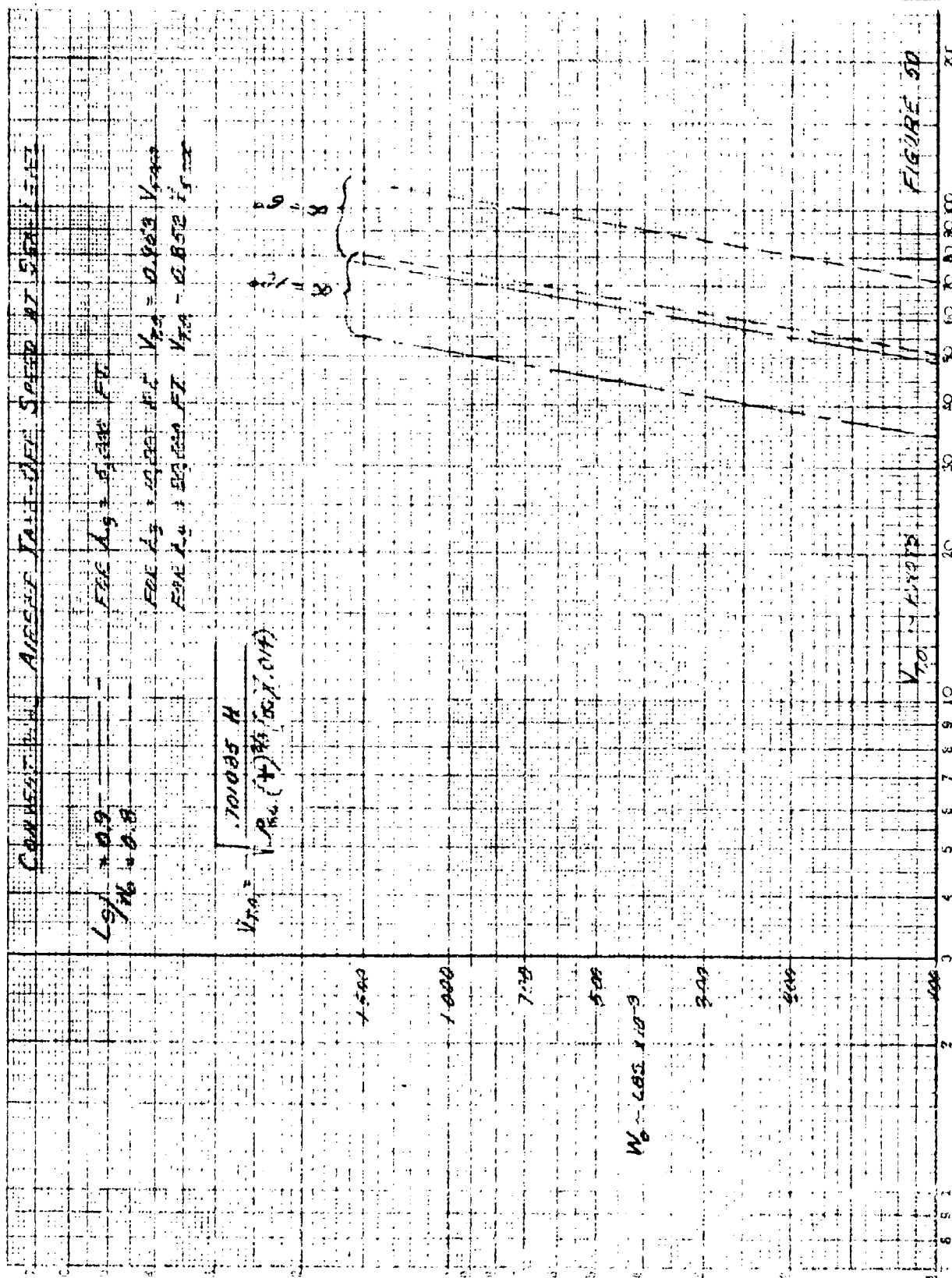
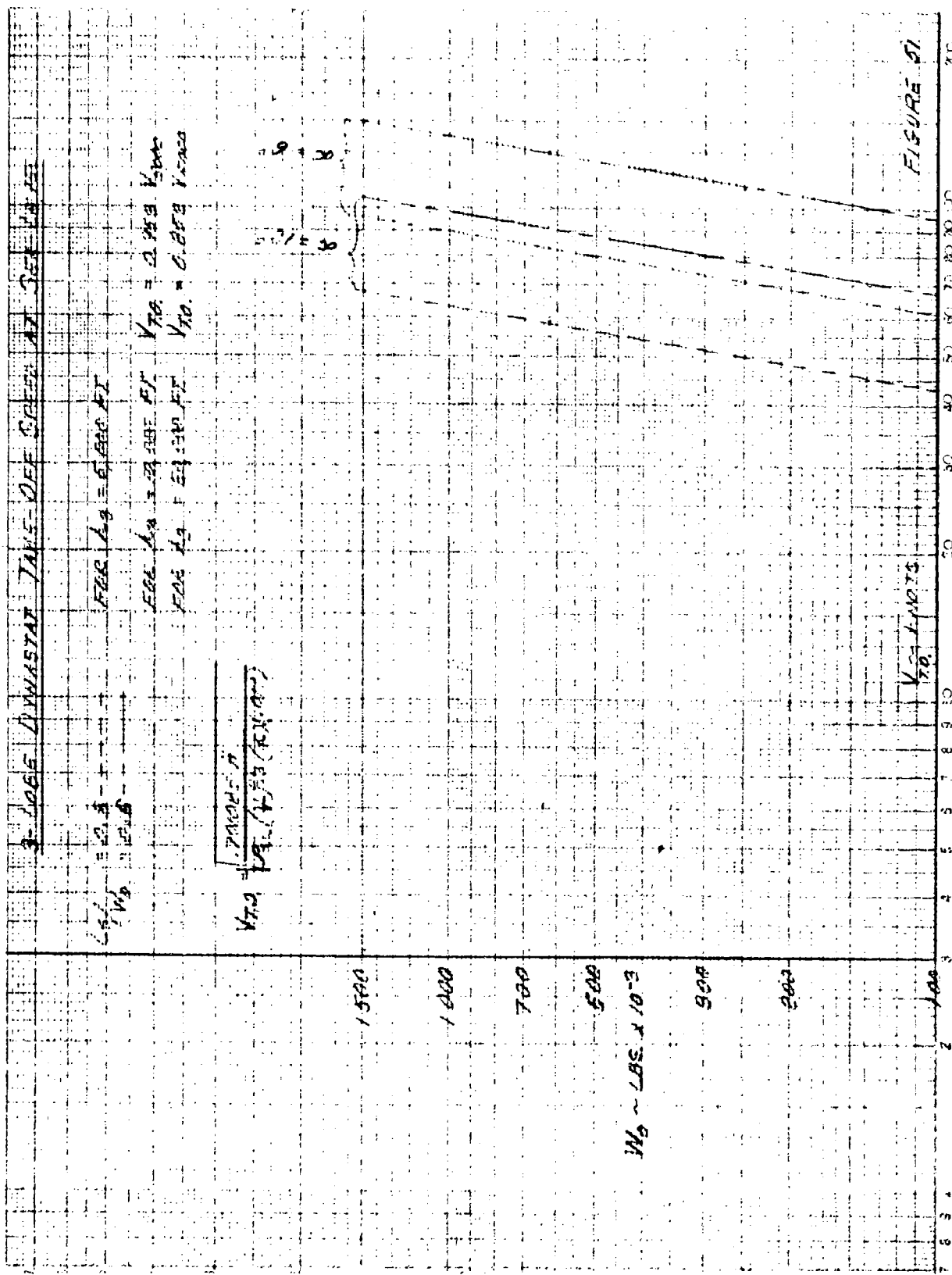


FIGURE 49





SECTION VII - OPERATIONAL CONSIDERATIONS

1. CREW ACCOMMODATIONS AND COMFORT

Airships, both rigid and non-rigid, traditionally have had comfortable but not luxurious accommodations for the crew. The configurations examined in this study are not exceptions. However, for the higher altitude configurations, consideration must be given to the increased structural weight of the pressurized compartment(s), to the pressurization/air-conditioning system, and to the portable/station oxygen system for emergency and inspection/maintenance use outside the pressure cabin.

These considerations will tend to keep the pressurized volume to the minimum required for reasonable crew comfort over a five-to-seven day flight.

The crew accommodations would consist of a flight control station, landing station, operating space for payload equipment, maintenance space and crew comfort spaces; i.e., facilities for sleeping, food preparation and eating, and off-duty activities.

Examples of two recent designs are given below.

The latest airship, the ZPG-3W carried a crew of 21. An upper deck of the car was devoted solely to crew's quarters. A bunkroom separate from the rest of the quarters contained nine bunks and lockers for personal effects. Aft of the bunkroom was a galley and eating facilities. The galley contained facilities for preparing hot meals, refrigeration for frozen and non-frozen food, a sink and stowage for cooking and eating utensils and for dry foods. The dining area contained comfortable seating at tables. These facilities doubled as a recreation area suitable for games, reading or writing. Heating and ventilation were controlled so that the sleeping area could be kept cooler for sleeping. Most toilet facilities were installed on the lower deck for isolation from the living quarters. These facilities consisted of toilets and wash basins with mirrors and shaver outlets. In addition a wash basin was installed on the upper deck. No showers were installed due to the weight of the water requirements. These facilities were provided at a weight of 2,000 pounds, exclusive of structure weight and empty of food.

Design and a mock-up for a larger airship (ZWG-1) were completed to the point where weights were quite firm. This airship would have carried a crew of 20 and had a greater endurance. The design provided similar accommodations to the ZPG-3W on one deck. These accommodations were somewhat roomier due to the availability of more space and included a shower. Accommodations for this airship were estimated to weigh 3,000 pounds.

Reference (20) is profusely illustrated with pictures of the interiors of the "Akron" and "Macon." These are typical of the quarters which can be available in any large airship.

2. NOISE LEVELS

No attempt has been made to arrive at definitive noise levels for the configurations studied. Noise level on the ZPG-3W is tabulated in Table VII-1 from Reference (35).

For any of the configurations studied, it is expected that the noise level would be appreciably less than on the ZPG-3W due to the greater separation of the crew compartments from the engines.

3. ALL WEATHER CAPABILITY

No vehicle is truly all-weather in that it can effectively perform its assigned mission in any weather condition which may occur. One possible exception is a submarine which operates at depths below weather effects.

However, many vehicles can survive severe weather conditions without damage to operational effectiveness and resume an operational mission after the weather has moved on. An airship with its remarkable endurance is one such airborne vehicle.

Wind has been the traditional handicap to the older slower airship models. Although high winds are not a threat to the structural integrity of an airship, they have hindered operational effectiveness, especially when a required course was into such a wind. However, the endurance of these airships has enabled them to ride out a storm, and resume operations as soon as the storm has passed. If high winds threaten an airship transit operation flying the pressure pattern will often permit an airship to arrive at its destination, whether it be an operating position or return to base, close to schedule.

TABLE VII-1
MEASURED SPL INSIDE COMPARTMENT - DB

Octave band C. P. S.	Electronic tech. compt.		AFT AEW		Center AEW		Lounge		Galley		Bunks and pilots' compt.	
	45K	T. O.	45K	T. O.	45K	T. O.	45K	T. O.	45K	T. O.	45K	T. O.
20-75	94	97	98	118	100	116	100	117	98	111	92	97
75-150	88	101	94	124	93	112	90	117	87	118	90	103
150-300	82	101	88	114	88	115	89	110	86	113	82	96
300-600	76	95	76	109	86	107	81	100	76	102	74	93
600-1200	74	87	72	94	72	95	71	94	72	93	69	83
1200-2400	73	77	70	87	71	88	68	83	72	82	68	78
2400-4800	65	68	66	80	66	80	63	79	65	71	63	66
4800-9600	60	66	58	84	60	84	65	84	62	74	65	65

REF: ENGINEERING PROCEDURE S.017

The higher speeds recommended for the vehicles in this study will overcome most of the inflight wind difficulties. The higher altitude capabilities of the configurations under study will enable them to fly over a significant portion of weather. Winds, especially turbulent winds, hamper ground operations of an airship. However airship endurance permits waiting for more favorable landing conditions or proceeding to an alternate base. An episode in the career of the Graf Zeppelin involved her waiting out a Brazilian revolution for three days off the coast before deciding that it was safe to proceed inland to a landing.

Previous airship models which were not flying statically heavy were able to pick up fuel from the runway or a truck on the runway if landing conditions were too turbulent. Inflight refuelling was accomplished by taking station over a naval surface tanker, winching up a fuel hose, and having fuel pressure-pumped aboard from the ship.

Icing, often a handicap to heavier-than-aircraft, has never been a severe problem to airships. Although airships had been flown for many years under conditions conducive to icing with no bad effects, a program was instituted in 1954, extending over three winters, to obtain more definitive data. A ZPG-2 airship with an envelope volume of 975,000 ft³, a length of 339 feet and maximum diameter of 75 feet, was instrumented and deliberately flown into weather conditions conducive to icing. In no case was ice accretion severe enough to affect airship control or flight characteristics, including one flight when an estimated 3,000 pounds of ice accumulated. The culmination of this test was a ten day patrol at a station off the east coast using five airships during January, 1957. During this period the worst conditions of icing, fog, sleet, snow, rain, and gale winds in many years were experienced. Thus a three-winter test formalized the experience of many years of prior airship operation with similar results.

Perhaps the most troublesome situation for a moored airship is the accumulation of a heavy, wet snow of several or more inches on the envelope and fin topsides. In several instances where this has unavoidably occurred, the Navy has flushed the snow off with a fire hose. Some promising experiments had been conducted in which the envelope helium was heated to melt the top-side snow, but the Navy did not think it necessary to make this operational.

Wet snow usually occurs near the ground and can be avoided in flight by a moderate increase in altitude.

Lightning has never caused concern with a helium-inflated airship. Although all aircraft attempt to avoid lightning areas, because of the turbulence that usually exists, there has been evidence of strikes on airship cars, fins, and topside radomes, but none causing detectable damage to an envelope. There have been reports of small holes in the covers of rigid airships, where charges hit the metal structure beneath, but the structure was not damaged.

4. VULNERABILITY TO WEAPONS

Very little is known about the vulnerability of airships to weapons fire. Experience is very limited and testing even more limited.

However, it is reasonable to believe that airships are no more vulnerable to the effects of weapons fire than other flight vehicles. In one respect airships offer a safety feature not available to other flight vehicles. Unless the envelope is shredded by enemy fire, severe damage to the car and/or power plants will not necessarily cause an immediate loss of craft and crew. The airship will lose altitude slowly - at a rate determined by the amount of envelope puncturing sustained - so that even with severe envelope damage the airship may safely reach the ground or even manage to be flown to home base.

Two historical instances bear this out. During WW-II an airship was shot down by a German submarine (the only such case on record). The airship settled slowly to the water with the loss of only one crewman. The airship floated for several hours after "landing" on the water.

In another instance an airship practicing carrier landings snagged a stern line and pulled a hole in the envelope described as "the size of two office desks." The airship slowly settled into the water and the entire crew was promptly rescued.

Envelope hits by solid or incendiary shells will cause damage directly proportional to the caliber and number of hits, with no tendency to tear the fabric. Explosive shells will probably cause more damage due to fragmentation effects. Blast effect from explosive shells would be small unless it occurred

within the envelope, in which case it could cause more severe damage to the envelope. No armor or self-sealing fuel tanks have been installed in earlier airships. Both, of course, could be installed as in other combat aircraft.

Conventional defensive weapons could easily be installed in an airship car or in appropriate pods on the envelope.

5. CREW SAFETY

A large proportion of the weight of an airship or DYNASTAT is sustained by its lifting gas. Therefore, it is a "forgiving" vehicle. Damage, or loss of power, or crew error do not necessarily mean that its ability to remain airborne is lost.

The airships and DYNASTATS described in this study are multiengined and are designed to fly on less than a full complement of engines. In the unlikely event of complete loss of power on all engines, the airship will still remain airborne and can be free-ballooned to a safe landing. Fuel and other weights can be jettisoned to reduce or eliminate a "heavy" condition under such circumstances.

Damage to the lift gas container(s) is not ordinarily catastrophic. Even with sizeable damage to the envelope the airship can be safely landed after a slow loss of altitude. An example of this occurred to one of the Goodyear-operated airships several years ago. An external generator threw a "V"-belt through the envelope causing an eighteen-inch tear. As the ship was quite heavy, the pilot was unable to return to base and landed, thirty minutes after the incident, at an unused airstrip. Emergency repairs prevented further loss of helium until the ground crew arrived. After temporary repairs and addition of helium, the airship was flown back to base for permanent repairs.

In another incident a few years ago, the advertising airship suffered abrupt loss of both engines during a cross-country trip in the St. Louis area during the winter. Water in the fuel had caused blockage by ice in the fuel lines. Fuel and other ballast was dropped until a neutral-buoyant condition was achieved. The two pilots aboard spent twenty minutes dismantling the fuel system in the car, eliminated the ice, and put the system back in service. The engines were restarted in the air and the ship flown to a base.

An inherent feature of the large rigid airships was nearly complete accessibility to all areas of the ship. Ordinarily, accessibility in the non-rigid, in flight, was limited to the car. However, many envelope areas could be reached through the airlines and ballonets. In the ZPG-3W airship, an enclosed vertical ladder provided connection to the car and access through the helium volume to the topside radar and control room located at the top of the envelope. Because of accessibility much more inflight inspection and maintenance is possible than with heavier-than-air craft. A variety of spare parts and tools were often carried to facilitate inflight repairs or maintenance of components.

Airship safety has been considered inherently so high that parachutes for the crew were seldom carried.

6. MAINTENANCE

Maintenance of an airship or DYNASTAT should prove similar to the maintenance of a heavier-than-aircraft. Some different skills are required. Such skills are relatively easy to learn, and personnel can be taught them in a short time.

An airship or DYNASTAT, because of its inherent size, has space available for equipment installations that have unusually easy access for maintenance. Space can be made available on such a ship for an inflight maintenance workshop. With such available facilities, many maintenance and repair functions can be accomplished during a mission thus salvaging a mission from termination. Similarly, many ground maintenance tasks, both scheduled and non-scheduled, can be performed on the ship without removal of the equipment to the ground maintenance shops.

For a brief description of the maintenance considerations, the airship or DYNASTAT has been divided into three arbitrary areas: (a) hull or envelope; (b) power plant; (c) payload.

(a) The hull of a rigid airship requires periodic inspection of structure much as would any metal heavier-than-aircraft. Although the entire airship structure is physically larger it is far more accessible than the structure, for instance, of an airplane wing. Repairs require the usual aircraft structural mechanic's skills. Only repair of major structural damage,

removal of upper control surfaces, or major overhaul would require hangaring the ship.

The outer skin and the lifting gas cells are of coated fabric and will require a knowledge of fabrics, adhesives, and elastomeric coatings. Inspection of all areas of the structure, skin and gas cells can be performed from within the ship, both inflight and on the ground. Temporary repairs to the skin and gas cells can be made in flight (and actually have, on occasion), and made permanent on the ground.

The DYNASTAT of this study is considered a non-rigid, or semirigid, type airship. It would not have the complete interior accessibility of the rigid airship but, by means of airlines and ballonets, as previously mentioned a considerable area of the interior of the envelope would be accessible from the inside. The same skills as required for the maintenance of a rigid airship would be required.

Helium in gas cells or an envelope becomes contaminated with air and water vapor over a period of time. Periodic purity samplings determine the condition of the gas. Gas purity can be improved by either of two methods. The U. S. Navy used a system called purging. Impure helium was bled off the bottom of the envelope and pure helium was added to the envelope. The impure helium was stored in low-pressure tankage and purified when convenient. Goodyear, in its advertising ship operation, utilizes a low-capacity, portable helium purifier which is connected to the envelope periodically. The helium in the envelope is slowly circulated through the purifier and returned directly to the envelope.

Flight control, communication, and flight instrumentation equipment would be standard aircraft equipment with the usual maintenance requirements.

Non-rigid airships require a pressurization system to maintain the envelope to the requisite tension for the flight or mooring condition existing. The pressurization system consists of ballonets, air lines, blowers, damper valves, and exhaust or pressure relief valves for the ballonets and helium compartments. The system can be automatic or manually-controlled. The valves and other elements of the pressurization system have been developed to a high degree of reliability and sensitivity. Only the helium pressure relief valves are required in a rigid airship.

(b) Power plants would be typical aircraft types. Inflight accessibility exists whether the engines are mounted within the hull or in outrigger cars. With a number of engines per ship, individual engines can always be shut down for minor inflight maintenance.

Suitable engine hoists and quick change engine stands would be required for engine changes. In the case of neutrally-buoyant airships which are weather-vaning on the mast, engine work or engine changes involve work platforms and hoists which are attached to the outriggers themselves and ride with the ship during the work time. The DYNASTAT, being tied down, could be worked on much as a conventional heavier-than-aircraft.

(c) Payload - If the payload is an electronics installation, maintenance is a function of the complexity of the equipment installed. As pointed out earlier, space is available on an airship to make equipment installations which provide ready access. This capability, coupled with space for spares, test equipment, and a repair shop makes for a very satisfactory electronics installation.

If the payload is cargo, maintenance would be limited to structural damage to the cargo hold or auxiliary handling equipment.

7. GROUND HANDLING

Ground handling is the technique of maneuvering and securing an airship on the ground from the time it touches down at the end of a flight until it takes off on another flight.

This consists of holding the ship into the wind until it can be attached to a mast, moving ship and mast to a mooring circle, moving the ship into and out of a hangar and moving it to a take-off position.

In recent years development of mechanical "mules" and mobile masts has greatly reduced manpower requirements for ground handling. The mechanical "mules" are highly maneuverable tractors with a constant-tension winch capable of accepting handling line loads from any direction. They are capable of restraining the ship and controlling the magnitude of the line loads. The number and size of the "mules" depends upon the size of the ship, the ground handling operation, and the wind conditions.

The DYNASTAT as a "heavy" aircraft would be handled much more as a heavier-than-aircraft. While parked it would be securely tied down. When ready for flight, it would be untied and taxi under its own power to a take-off location.

Airships or DYNASTATs would be provided appropriate shore power and other facilities while on the ground. Previous mooring circles at Naval bases provided, through the mast, electrical connections, telephone connections and other services.

B-1D-15(7-63)(77-20)

REF. ENGINEERING PROCEDURE S-017

SECTION VIII - COSTS

Cost data in this section is based on historical data from Navy airship operations, Goodyear data, and on assumptions made with respect to larger sizes and greater complexities and configurations for which no data is available.

1. DEVELOPMENT AND PRODUCTION COSTS

Design, development, prototype, and production costs are based on actual costs of the latest non-rigid airship, ZPG-3W, with the costs updated to 1967 dollar values at 1.3 times the original actual costs. Costs for a rigid airship are estimated to be 2.0 times the cost of an equivalent sized non-rigid airship and the DYNASTAT costs are estimated to be 1.7 times that of a non-rigid. Base costs are for a non-rigid airship of 1,500,000 cubic feet volume. To estimate costs for the larger size flight vehicles considered in this report, the following factors were applied:

1. Design/development - 20 percent of the cost of the previous size has been added each time the volume has been doubled.
2. Prototype - 50 percent of the cost of the previous size has been added each time the volume has been doubled.
3. Production (based on one unit of a first production lot of three units) - 50 percent has been added each time the volume has been doubled.

Engines, flight instruments, and communications equipment are considered to be government furnished equipment in accordance with standard practice and are not included in the costs shown.

Payload electronics equipment is not included.

Table VIII-1 lists costs for the configurations examined in this study.

Figure 52 is a plot of these costs for use in estimating costs for vehicle sizes not shown in Table VIII-1.

TABLE VIII-1
DESIGN/DEVELOPMENT - PROTOTYPE - PRODUCTION COSTS

	W _o - gross weight - lbs.			
	100,000	250,000	625,000	1,500,000
Design/development				
Non-rigid	\$42,000,000	\$54,000,000	\$64,000,000	\$82,000,000
Rigid	69,000,000	85,000,000	109,000,000	136,000,000
DYNASTAT	—	64,000,000	81,000,000	102,000,000
Prototype				
Non-rigid	19,000,000	30,000,000	54,000,000	82,000,000
Rigid	32,000,000	47,500,000	86,000,000	140,000,000
DYNASTAT	—	32,000,000	54,000,000	88,000,000
Production (each in lots of 3)				
Non-rigid	7,100,000	11,200,000	18,400,000	32,000,000
Rigid	14,200,000	22,500,000	37,500,000	63,500,000
DYNASTAT	—	14,200,000	24,000,000	40,000,000

NOTE: Design/development costs include engineering, documentation, and testing.

2. GROUND SUPPORT EQUIPMENT (GSE)

Ground support equipment is that equipment necessary to handle the vehicle on the ground, such as masts, "mules", tractors, and tie-downs and that equipment necessary for the maintenance of the vehicle on the ground. This latter equipment includes work stands, engine hoists, jacks, electric power units, heaters or air conditioners, helium purifiers, test equipment, and tools.

The cost of this equipment is estimated to be 20 percent of the cost of a production non-rigid airship, 12 percent of a rigid airship, and 10 percent of the cost of a DYNASTAT. Table VIII-2 shows the cost of GSE for the first vehicle of each type. Costs for GSE for additional vehicles would be at a reduced percentage.

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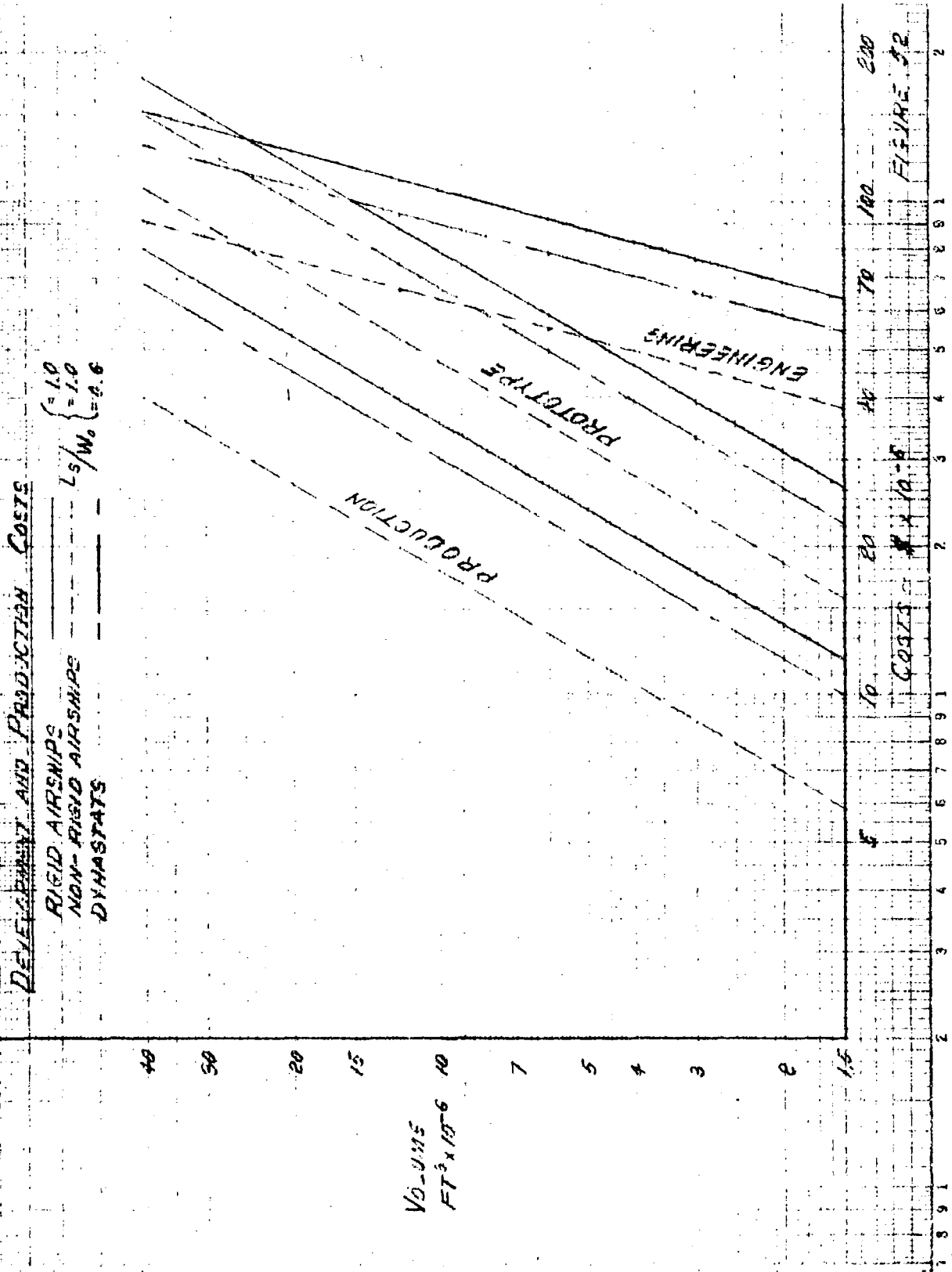


TABLE VIII-2
GROUND SUPPORT EQUIPMENT COSTS

W _o , gross wt.	100,000	250,000	625,000	1,500,000
Non-rigid	\$1,420,000	\$2,240,000	\$3,680,000	\$6,400,000
Rigid	1,788,000	2,772,000	4,813,000	7,920,000
DYNASTAT	—	1,420,000	2,400,000	4,000,000

No operating base costs are included since it is assumed that the vehicles would be assigned to existing, though presently deactivated, facilities and base costs would be only activation costs.

3. OPERATING AND MAINTENANCE COSTS

Operating and maintenance costs are grouped together in Table VIII-3. However, the headings are such that costs may be separated if desired.

Ships of lower design speed than the 140 knot speed of Table VIII-3 would differ primarily only in those costs affected by the lower installed horsepower.

Following Table VIII-3 are the assumptions made in computing the operating costs.

a. Helium Costs

Helium costs vary widely depending on whether the user is a commercial user or a government agency. To government agencies the cost represents little more than transportation costs, at this time approximately \$35.00/- thousand cubic feet.

It is assumed that the vehicles under study in this report will be based at existing facilities with railroad car and storage facilities.

Approximately one ship volume per year is the average helium loss from diffusion and valving.

b. Fuel and Oil Costs

A specific fuel consumption of 0.50 lbs./HP/hr. was used. Oil consumption was assumed to be 6.5 percent of the fuel consumption. A fuel cost of

TABLE VIII-
ESTIMATED YEARLY OPER

	Non-rigid airship					
Gross weight (lbs)	100,000	250,000	625,000	1,500,000	100,000	2
Lift gas volume (ft ³)	2,100,000	4,600,000	11,500,000	27,000,000	2,100,000	4,6
Horsepower required	8,000	13,500	23,000	40,000	6,800	
Number engines required	2	3	5	9	2	
Helium	\$ 63,000	\$ 138,000	\$ 345,000	\$ 810,000	\$ 63,000	\$ 1
Fuel and oil	639,000	1,078,000	1,837,125	3,195,000	543,150	9
Envelope replacement and empennage recover	396,890	794,740	2,193,280	5,071,200	—	
Gas cell replacement skin and empennage recover	—	—	—	—	710,000	1,1
Engine overhaul	62,000	93,000	155,000	297,000	62,000	
Air frame overhaul	177,500	280,000	460,000	800,000	355,000	5
Spares	876,000	1,398,000	2,445,000	4,107,000	1,842,000	2,9
Ground support equipment spares	142,200	224,000	368,000	640,000	178,800	2
Yearly total operating costs	2,356,590	4,005,740	7,803,405	14,920,200	3,753,950	6,0
Total operating costs per flight hour	785.53	1,335.24	2,601.13	4,973.40	1,251.31	2,0

NOTE: The calculations above are based on 3000 flight hours per year, at 140 knots at 10,000 ft alti
stallation.

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TABLE VIII-3

YEARLY OPERATING COSTS

Rigid airship				DYNASTAT			
100,000	250,000	625,000	1,500,000	100,000	250,000	625,000	1,500,000
2,100,000	4,600,000	11,500,000	27,000,000	—	2,760,000	6,900,000	16,200,000
6,800	12,000	21,000	35,000	—	14,000	26,000	46,000
2	3	5	8	—	3	6	10
63,000	\$ 138,000	\$ 345,000	\$ 810,000	\$	82,800	\$ 207,000	\$ 486,000
543,150	958,500	1,677,375	2,795,625		1,118,250	2,076,750	3,674,250
—	—	—	—		953,825	2,746,200	6,195,000
710,000	1,125,000	1,875,000	3,225,000		—	—	—
62,000	93,000	155,000	248,000		93,000	186,000	310,000
355,000	562,500	937,500	1,587,500		355,000	600,000	1,000,000
1,842,000	2,928,000	5,154,000	8,865,000		1,809,000	2,820,000	4,713,000
178,800	277,200	481,200	792,000		142,000	240,000	400,000
3,753,950	6,082,200	10,625,075	18,323,125		4,553,875	8,875,950	16,778,250
1,251.31	2,027.40	3,541.69	6,107.71		1,517.95	2,958.65	5,592.75

at 10,000 ft altitude. All engines are 5000 HP reciprocating, not optimized for a particular in-

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\$0.30/gallon, and a utilization of 3,000 hours per year was assumed. The yearly fuel and oil costs per vehicle may then be calculated by the following equation:

$$\text{Fuel cost} = \frac{\text{HP} \times 0.50 \times \$0.30 \times 1.065 \times 3,000}{6}$$

c. Envelopes, Empennages, Gas Cells, and Outer Covering

For non-rigid airships, the envelope should be replaced and the empennage should be recovered every four years as an average. Actual times will be based on the results of periodic fabric sample testing of ship fabric. DYNASTATS would require identical treatment.

A rigid airship requires replacement of the lift gas cells and recovering of empennage and structure outer cover on the same schedule.

The envelope of a non-rigid airship represents approximately 15 percent of the total production cost of the airship. However, as the size of the airship increases, the envelope becomes a larger percentage of the total cost because the car and other hard structure does not increase in size and complexity proportionally. A 10 percent increase in the envelope percentage for each doubling in volume is assumed. The initial volume used is 1,500,000 cubic feet.

The empennage represents approximately 10 percent of the total cost of a 1,500,000 cubic foot non-rigid airship. An increase in percentage of 3 percent each time the volume is doubled is used for empennage costs. Recovering cost is estimated at 30 percent of the cost of the empennage.

The computed costs for the above items are divided by four to obtain yearly dollar values for the operating costs of Table VIII-3.

The DYNASTAT is considered to be similar to a non-rigid airship and empennage and envelope replacement costs are treated in the same manner as for the non-rigid airship.

d. Engine Overhaul

These costs are based on a \$4,000 cost to overhaul a 1275 HP engine every 1120 hours of operation. This is approximately \$3.10/HP. The overhaul

cycle has been extended to 1500 hours to make an even two overhauls per year. Thus the overhaul costs per engine per year are \$15,500 (for 5,000 HP engines). This figure times the number of engines per vehicle gives the engine overhaul costs per vehicle.

e. Airframe Overhaul

Overhaul costs of the airframe are estimated at 10 percent of the total production cost. This cost is spread over the four-year period between overhauls.

f. Spare Parts

From a twenty-one month study of operating costs of an AEW airship squadron conducted in 1957-1959, maintenance spare parts were found to cost approximately \$150.00 per flight hour. Brought up to 1967 dollars, this is approximately \$186.00 per flight hour for a 975,000 cubic foot non-rigid airship, flying approximately 1,464 hours per year.

Costs are brought up to the volumes in this study by increasing costs 50 percent for each 100 percent increase in volume for a non-rigid airship.

Costs for a rigid airship are considered to be 2.0 times a non-rigid airship and for a DYNASTAT to be 1.7 times a non-rigid. All are computed for 3,000 flight hours per year.

g. Ground Support Equipment Spares

Cost of GSE spares is assumed to be 10 percent of the initial cost of the GSE per year. Costs shown are for one vehicle only.

h. Personnel

No attempt is made to assign personnel costs to the vehicles described herein because of the large number of variables associated with the number, size, and complexity of the vehicles themselves and the type of mission which the operating unit performs.

A review of the parameters influencing the size and composition of operating unit personnel indicates that there should be only minor differences in personnel requirements among the three configurations, if they are similar in size, function, and mission schedule.

SECTION IX - CONCLUSIONS

1. HEAVINESS, SPEED, GROSS WEIGHT, AND VOLUME RELATIONSHIPS

The primary attraction of "heavy" flight with a displacement aircraft (aside from ground handling, which is discussed elsewhere) is the expectation of a physically smaller vehicle for a given gross weight.

The amount of ratio of heaviness desirable increases with increasing design velocity, and decreases with increasing gross weight (a "wing-loading" effect). In other words as gross weights increase and the ship becomes physically larger, it should tend toward higher design speeds at which speeds it can handle greater dynamic lifts. At 70 knots design speed and within the gross weights studied the advantages from a total payload basis and minimum power basis are with essentially neutrally-buoyant flight. In this speed regime conventional airships configured for minimum hull drag would be optimum.

At 140 knots and higher, minimum power and maximum payload are achieved by "heavy" flight. It is also apparent that L_s/W_o ratios smaller than 0.8 for conventional airships and 0.6 for the DYNASTAT would be desirable, especially in the lower gross weights.

2. PROPULSION - ENGINE TYPES AND SIZES

For maximum range or endurance, slow - and, therefore, nearly buoyant - flight is indicated. Heavier installed power plants can be accepted in the lower V_{max} ships if such power plants offer lower B. S. F. C. for the greater part of the mission. For ships with widely varying speed or power requirements throughout their missions, a mixture of engine types and sizes may be optimum: large turbo-props for the high power requirement (minimum installed weight) plus Diesel or reciprocating gasoline engines for prolonged cruising. Compatibility of fuel or separate fuels and systems would be additional considerations.

Ships in the higher speed range, such as 140 knots or higher, have greater incentive to smaller L_s/W_o ratios and lighter power plants such as the turbo-props. Figures 16A and 22A show considerable improvements in payload capability which make vehicles possible where heavier power plant installations eliminate them. Similar improvements in

conventional airship payloads at these speeds would occur for turbo-props rather than reciprocating engine installations.

Fuel flows can be estimated for a turbo-prop installation by using B. S. F. C. figures of Table A-7 and the appropriate horsepowers of the performance tables in Section IV.

EFFECT ON $W_{F + PL}$ OF SUBSTITUTION OF LIGHTER-WEIGHT TURBO-PROPS FOR RECIPROCATING ENGINES	
<u>Parameter</u>	
V_K	Minimal in rease in $W_{f + pl}$ at 70 knot design: considerable increase in $W_{f + pl}$ at 140-210 knot design
W_o	Greatest increase at lowest W_o .
L_s/W_o ratio	Greatest increase for $L_s/W_o = 1.0$.
h_3	Percent increase is virtually unchanged from $h_3 = 5,000$ ft to $h_3 = 20,000$ ft

3. VTOL CAPABILITY

Based on five pounds/brake horsepower, no heavy ships - $L_s/W_o = 0.9$ or less - required enough thrust power to have, as a consequence, VTOL capability for 70 knot design velocity.

At 140 knot design velocity, DYNASTATS of $L_s/W_o = 0.8$ had VTOL capability throughout the gross weight range. Conventional airships, $L_s/W_o = 0.8$, had VTOL capability up to 250,000 pounds gross. At $L_s/W_o = 0.9$, conventional airships had VTOL capability to 1,500,000 pounds gross. At 210 knot design, conventional airships of $L_s/W_o = 0.8$ had VTOL capability.

4. ALTITUDE AND SPEED TRADE-OFFS

Altitude capability of 20,000 feet rather than 5,000 feet costs 13-22 percent of the total low altitude payload capability, depending upon vehicle gross

weight and design velocity. Payloads for 5,000 foot design altitude and 20,000 foot design altitude compare as follows, when the ships are powered by reciprocating engines:

$V_k = 70$ knots	W_o
$W_{f+pl_{20,000}} = 87\% W_{f+pl_{5,000}}$	1,500,000 lbs.
$W_{f+pl_{20,000}} = 80\% W_{f+pl_{5,000}}$	100,000 lbs.
$V_k = 140$ knots	W_o
$W_{f+pl_{20,000}} = 84\% W_{f+pl_{5,000}}$	1,500,000
$W_{f+pl_{20,000}} = 74\% W_{f+pl_{5,000}}$	250,000
$V_k = 210$ knots	W_o
$W_{f+pl_{20,000}} = 78\% W_{f+pl_{5,000}}$	1,500,000

Speed costs payload both in higher structural weights and greater installed power plant weights. The minimum-weight conventional ships with reciprocating engines and water recovery apparatus which have the design speed capabilities with zero payload are:

V_k	W_o	
70 knots	40,000 lbs.	} $h_3 = 5,000$ ft
140 knots	98,000 lbs.	
210 knots	300,000 lbs.	

Speed affects payload most adversely at the lower gross weights. At $W_o = 1,500,000$ lbs., W_{f+pl} equals the following percentage of W_o when ships are powered with reciprocating engines:

W_{f+pl}	V_k	
67% W_o	70 knots	} for $W_o = 1,500,000$ lbs. and $h_3 = 5,000$ feet
52% W_o	140 knots	
30% W_o	210 knots	

5. BALLASTING AND OTHER MEANS OF MAINTAINING NEUTRAL BUOYANCY

Neutrally-buoyant airships have usually had the problem of excess lift as fuel weight is diminished. Valving of lifting gas is the obvious but expensive expedient. Ballasting by means of condensation of water vapor in the engine exhaust was the technique on several large rigids. With sufficient condensation apparatus, an excess of ballast can be manufactured for storage in emptied fuel tanks.

Some of the Naval "blimps" ballasted by dipping up sea water for storage in emptied fiberglass fuel tanks.

On occasion attempts have been made to recover fresh water from rain run-off of the envelope. It is not known that this technique was ever utilized intentionally and deliberately for reballasting.

The "Graf Zeppelin" evaded the ballasting problem by fueling with "Blaugas", a gaseous fuel probably close to a blend of methane and propane. This gas had a specific gravity of 1.09 in relation to air so that it affected the ship heaviness very little as it was consumed. Ship total volume is the same since, on an equal BTU basis, the volume of helium to lift a given quantity of liquid fuel is approximately the same as the volume of the equivalent gaseous fuel.

Another technique which could be used would be the burning of gaseous hydrogen with liquid fuel. The hydrogen would be separately ballonetted within the main helium volume for isolation from the atmospheric oxygen. If burned at a 17 percent hydrogen, 83 percent liquid fuel rate, on a BTU basis, break-even on lift and weight would be maintained.

6. PAYLOAD AND RANGE

With a ratio of $L_s/W_o = 1.0$ the range will be directly proportional to fuel supply for any constant speed. With any "heavy" ship the earlier part of a mission will be flown at higher speeds, and cost more fuel than the later stages of the mission. At a given gross weight, power requirement generally reduces and payload increases with decreased L_s/W_o ratio, as one looks at the higher design speed regimes (140 knots and higher).

The payload to HP ratios (figures 20-23) indicate the effects of varying gross weight, design speed, and L_s/W_o ratio. The higher figures of $W_f + p_l/BHP$ are in the direction of greatest range or endurance. In the case of "heavy" ships, these figures represent initial conditions.

7. FUTURE STRUCTURAL IMPROVEMENTS

Figure 45 of Section VI suggest the possibility of dramatic savings in structural weight of a metal-skinned non-rigid or pressure airship. The figure indicates potential savings of 2/3 to 3/4 of the envelope weight by the substitution of aluminum for the conventionally-used coated fabric envelope. The applicability is to either a conventional or DYNASTAT-type of airship configuration. As pointed out in Section VI some of the weight saving may well be lost in the details of joint and suspension design. The problems of fabrication and construction appear more formidable than for fabric construction. An incidental bonus of such a construction would be helium losses becoming primarily a function of the quality of the joining of sections, rather than permeation through the cover.

8. GROUND HANDLING

Ground handling of conventional airships was well-mechanized by 1960. Ships were moored at the apex of the bow to self-propelled or towable masts. Vehicular "mules" with constant-tension winches were secured to handling lines from either side of the tail when the ship was moved. When moored, the ship was free to weathervane about the mast to minimize loads on the hull. The large rigids were sometimes secured by the lower fin to a

riding-out car which permitted weathervaning but prevented the tail from being carried up.

Ships were moved to a take-off location by towing on the mast. Upon release, the mast was withdrawn laterally. A buoyant ship merely flew away; a "heavy" ship made a running take-off on its wheel gear.

Recovery was accomplished by attaching a bow line from the ship to a line from the mast, and winching the ship to the mast. After locking a spindle into a cup on the mast, the ship was towed to a parking area or mooring-out circle.

The DYNASTAT, operating always "heavy", is expected to be maneuvered on the ground much as a heavier-than-aircraft. It should be able to park and unpark and taxi on its own, without masts and handling "mules". When not about to fly, a DYNASTAT would be secured to ground anchors without the necessity for freedom to weathervane.

Ground blower equipment or shore power, helium purification apparatus, etc., would be similar for either conventional non-rigid or DYNASTAT-type airships.

9. RECOMMENDATIONS

Further investigation of future, large airships - whether DYNASTAT or conventional - should include a detailed study of the pressurized, metal hull. The possibility of considerably diminished structural weight emerges from the work of Section V, as long as the design envisioned is not so small or so slow (lightly-loaded) as to be below minimum gage requirements.

Exploitation of the dynamic-lift concept warrants more sophisticated wind-tunnel configurational development and should include model testing against conventional airship bodies in the same tunnel. Existing data from a multitude of sources are subject to discrepancies impossible to eliminate without comparative testing. Ideally a family of dynamic-lift bodies with optimum characteristics at different L_s/W_o ratios should be developed. VTOL capability should be a prime concern in such configuration development.

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APPENDIX A

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Appendix A

AERODYNAMIC AND AEROSTATIC RELATIONSHIPS

Helium Unit Lift at sea-level standard conditions:

$$.0635 \text{ lb/ft}^3 \text{ (96.3\% purity)}$$

Envelope Volumes:

$$\Psi = \frac{\left(\frac{L_s}{W_o}\right) W_o}{.0635 \left(\frac{w}{w_{S.L.}}\right) .935} \quad \text{For Rigids}$$

$$\Psi = \frac{\left(\frac{L_s}{W_o}\right) W_o}{.0635 \left(\frac{w}{w_{S.L.}}\right)} \quad \text{For Non-Rigids and "Dynastats"}$$

For design altitudes, h_3 :

h_3	$\frac{w}{w_{S.L.}}$
5,000 ft	.86170
10,000 ft	.73859
20,000 ft	.53316

Drag Equations:

Rigid:

$$\text{Drag} = q \left[(.213) \left(\frac{V_k \Psi^{1/3}}{Y} \right)^{-.145} (\Psi^{2/3}) + 15.0 + 0.9 C_L^2 (\Psi^{2/3}) \right]$$

Non-Rigid:

$$\text{Drag} = q \left[(.289) \left(\frac{V_k \Psi^{1/3}}{Y} \right)^{-.154} (\Psi^{2/3}) + 19.7 + .0000003 \Psi - \frac{50}{(.00001 \Psi)^2} + 0.9 C_L^2 (\Psi^{2/3}) \right]$$

3-Lobe DYNASTAT:

$$\text{Drag} = q \left[(.427) \left(\frac{V_k \Psi^{1/3}}{Y} \right)^{-.154} (\Psi^{2/3}) + 17.5 + 0.42 C_L^2 (\Psi^{2/3}) \right]$$

For idealized "DYNASTAT" (.427) reduced to (.350)

5-Lobe DYNASTAT:

$$\text{Drag} = q \left[(.483) \left(\frac{V_k \Psi^{1/3}}{Y} \right)^{-.154} (\Psi^{2/3}) + 17.5 + 0.46 C_L^2 (\Psi^{2/3}) \right]$$

$$\text{where } q = \frac{1}{2} \rho v^2 = 1.42636 \left(\frac{w}{g} \right) V_k^2$$

Lift Equations:

For all "heavy" ships:

$$C_L = \frac{2 \left(1 - \frac{L_s}{W_o} \right) W_o}{\frac{w}{g} v^2 (\Psi^{2/3})} = \frac{.701085 \left(1 - \frac{L_s}{W_o} \right) W_o}{\frac{w}{g} (V_k^2) (\Psi^{2/3})}$$

Slope of lift curves:

/Degree

Rigid		.0150
Non-Rigid		.0140
3-Lobe	} "DYNASTATS" {	.0190
5-Lobe		.0395
7-Lobe		.0698

Angle of attack:

$$\alpha = \frac{C_L}{C_{L/\text{Degree}}}$$

Propulsive Thrust

Propulsive thrust is calculated from the following relation:

$$T = \frac{\text{BHP} \times 550 \times \eta}{V_k \times 1.689} \quad \text{where } T = \text{total propulsive thrust (including nacelle drag)}$$

η = propulsive efficiency

V_k = velocity in knots

$$\begin{aligned}\eta &= 0.85 && 140 \text{ knots through 210 knots} \\ &= 0.70 && 30 \text{ knots through 70 knots} \\ T &= 277 \frac{\text{BHP}}{V_k} && \text{from 140 knots through 210 knots} \\ T &= 288 \frac{\text{BHP}}{V_k} && \text{from 30 knots through 70 knots}\end{aligned}$$

Using straightline thrust factor relationship between 70 knots and 140 knots:

V_k	Thrust Factor
30	228
70	228
80	235
90	242
100	249
110	256
120	263
130	270
140	277
210	277

$$\text{BHP} = \frac{TV_k}{277} = \frac{(\text{Drag}) V_k}{277} \sim 140 \text{ knots through 210 knots}$$

$$\text{BHP} = \frac{(\text{Drag}) V_k}{228} \sim 30 \text{ knots through 70 knots}$$

Speeds for Maximum Endurance or Maximum Range

Maximum endurance (time in the air) will be at the speed of minimum horsepower requirement. Two-hundred horsepower will be considered a constant on-board requirement for generation of electricity and "housekeeping". Thirty knots will be considered a minimum speed for controllability; otherwise a ship at $L_s = 1.0$ would have zero speed for maximum endurance.

$$\frac{W}{W_o}$$

The velocity for maximum endurance, if greater than 30 knots, is the speed at which aerodynamically required BHP is a minimum.

$$\text{BHP}_{\min} = \frac{(\text{Drag})V_k}{277} = \text{Minimum (140K to 210K)}$$

$$\text{BHP}_{\min} = \frac{(\text{Drag})V_k}{228} = \text{Minimum (30K to 70K)}$$

Maximum range is the velocity at which the ratio of total horsepower to velocity is least. With 200 HP as a constant on-board requirement, the determination of velocity for maximum range is: $\frac{(228) 200 + (\text{Drag})V_k}{(228)V_k} = \text{Minimum (30K to 70K)}$

$$\text{or } \frac{(277) 200 + (\text{Drag}) V_k}{(277)V_k} = \text{Minimum (140-210K)}$$

Use thrust factors above for other velocities.

TABLE A-1

NON-RIGID CONVENTIONAL AIRSHIPS
DRY STRUCTURAL WEIGHT - LESS POWER EGG

$$\frac{L_s}{W_o} = 1.0$$

V _k Knots	Altitude Feet	Volume - Ft. ³ × 10 ⁶					
		1	5	10	15	20	25
70	1,500	24,440	78,800	140,220	198,870	254,750	310,460
	10,000	24,100	76,650	135,810	192,690	246,390	300,230
	20,000	24,050	72,980	127,740	183,160	236,470	287,500
140	1,500	34,020	120,410	221,500	317,950	414,040	505,300
	10,000	31,740	109,140	199,200	285,030	370,450	453,630
	20,000	29,870	94,260	168,400	242,910	315,050	385,170
210	1,500	46,510	173,350	323,430	469,600	612,300	752,090
	10,000	41,700	160,440	279,200	404,220	525,420	645,510
	20,000	37,490	119,720	216,380	312,880	406,400	499,270

$$\frac{L_s}{W_o} = 0.9$$

70	1,500	25,220	85,140	156,040	225,420	294,400	359,190
	10,000	24,770	81,470	147,830	212,750	276,830	339,810
	20,000	24,480	77,580	137,290	197,900	255,980	312,330
140	1,500	34,820	126,820	237,370	344,710	453,940	554,790
	10,000	32,420	113,990	211,270	305,140	401,040	493,360
	20,000	30,310	98,870	177,970	257,680	334,590	410,050
210	1,500	47,330	179,810	339,420	496,410	652,300	801,170
	10,000	42,390	165,320	291,320	424,380	556,060	685,290
	20,000	37,940	124,370	226,000	327,700	425,990	524,300

TABLE A-1 (cont)

NON-RIGID CONVENTIONAL AIRSHIPS
DRY STRUCTURAL WEIGHT - LESS POWER EGG

$$\frac{L_s}{W_o} = 0.8$$

V _k Knots	Altitude Feet	Volume - Ft ³ × 10 ⁶					
		1	5	10	15	20	25
70	1,500	26,000	91,480	171,860	251,970	334,050	407,920
	10,000	25,440	86,290	159,850	232,810	307,270	379,390
	20,000	24,910	82,180	146,840	212,640	275,490	337,160
140	1,500	35,620	133,230	253,240	371,470	493,840	603,720
	10,000	33,100	118,840	223,340	325,250	431,630	533,090
	20,000	30,750	103,480	187,540	272,450	354,130	434,930
210	1,500	48,150	186,270	355,410	523,220	692,300	850,250
	10,000	43,080	170,200	303,440	444,540	586,700	725,070
	20,000	38,390	129,020	235,620	342,520	445,580	549,330

TABLE A-2

RIGID CONVENTIONAL AIRSHIPS
DRY STRUCTURAL WEIGHTS - LESS POWER EGG

$$\frac{L_s}{W_o} = 1.0$$

V _k Knots	Altitude Feet	Volume - Ft. ³ × 10 ⁶				
		3	10	20	30	40
70	1,500	68,550	176,760	313,310	438,690	562,350
	10,000	62,950	163,740	289,500	403,860	516,620
	20,000	59,270	150,730	267,880	375,840	482,350
140	1,500	95,970	237,440	417,720	573,780	730,560
	10,000	85,430	213,060	370,910	516,600	657,670
	20,000	76,410	190,390	334,170	465,290	594,480
210	1,500	113,790	290,950	505,540	703,100	896,590
	10,000	104,130	260,770	454,930	632,420	807,250
	20,000	91,590	228,510	398,300	555,150	708,220

$$\frac{L_s}{W_o} = 0.9$$

70	1,500	71,950	191,560	350,010	500,190	649,930
	10,000	65,550	175,340	317,900	451,260	584,020
	20,000	61,370	159,530	287,280	406,440	524,550
140	1,500	99,370	252,240	454,420	635,280	818,160
	10,000	88,030	224,660	399,310	564,000	725,070
	20,000	78,510	199,190	353,570	495,890	636,680
210	1,500	117,190	305,750	542,240	764,600	984,190
	10,000	106,730	272,370	483,330	679,820	874,650
	20,000	93,690	237,310	417,700	585,750	750,420

TABLE A-2 (cont)

RIGID CONVENTIONAL AIRSHIPS
DRY STRUCTURAL WEIGHTS - LESS POWER EGG

$$\frac{L_s}{W_o} = 0.8$$

V _k Knots	Altitude Feet	Volume - Ft. ³ × 10 ⁶				
		3	10	20	30	40
70	1,500	75,350	206,360	386,710	561,690	737,550
	10,000	68,150	186,940	346,300	498,660	651,420
	20,000	63,470	168,330	306,680	437,040	566,750
140	1,500	102,770	267,040	491,120	696,780	905,760
	10,000	90,630	236,260	427,710	611,400	792,470
	20,000	80,610	207,990	372,970	526,490	678,880
210	1,500	120,590	320,550	578,940	826,100	1,071,790
	10,000	109,330	283,970	511,730	727,220	942,050
	20,000	95,790	246,110	437,100	616,350	792,620

REF. ENGINEERING PROCEDURE S.017

TABLE A-3

3-LOBE DYNASTAT AIRSHIPS - LESS POWER EGG

$$\frac{L_s}{W_o} = 1.0$$

V _k Knots	Altitude Feet	Volume - Ft. ³ × 10 ⁶				
		5	10	15	20	25
70	5,000	82,610	147,100	208,420	272,100	333,830
	10,000	80,330	142,520	201,960	262,760	322,250
	20,000	75,310	131,100	191,130	243,200	296,800
140	5,000	137,680	247,040	357,480	465,550	569,370
	10,000	125,930	224,850	324,380	421,950	517,030
	20,000	107,380	188,590	272,970	353,430	431,900
210	5,000	...	...	537,150	690,990	881,370
	10,000	...	...	472,550	606,680	775,790
	20,000	...	...	372,950	477,410	606,480

$$\frac{L_s}{W_o} = 0.8$$

70	5,000	92,590	167,190	241,450	323,550	408,160
	10,000	88,140	160,640	233,230	308,990	383,240
	20,000	81,830	141,660	204,960	271,300	337,170
140	5,000	147,140	275,660	405,480	535,090	664,600
	10,000	133,010	247,650	362,320	477,320	595,800
	20,000	113,730	205,910	300,360	390,970	484,980
210	5,000	...	399,330	593,670	786,780	982,390
	10,000	...	349,200	517,560	684,180	856,800
	20,000	...	275,220	405,770	531,860	663,070

REF: ENGINEERING PROCEDURE S.017

TABLE A-3 (cont)

3-LOBE DYNASTAT AIRSHIPS - LESS POWER EGG

$$\frac{L_s}{W_o} = 0.6$$

V _k Knots	Altitude Feet	Volume - ft ³ × 10 ⁶				
		5	10	15	20	25
70	5,000	106,670	199,430	309,300	425,160	529,640
	10,000	99,430	186,120	281,800	386,260	484,820
	20,000	91,330	161,230	245,930	327,620	407,350
140	5,000	160,860	307,360	462,780	620,350	763,670
	10,000	143,990	273,060	408,180	546,550	677,790
	20,000	122,760	225,040	333,930	438,260	540,400
210	5,000	. . .	432,860	642,440	871,790	1,084,400
	10,000	. . .	376,100	556,070	753,380	942,000
	20,000	. . .	295,470	433,890	578,780	720,380

TABLE A-4

POWER EGG WEIGHTS - POWER PLANT AND INSTALLATION

1	2	3	Based on S. L. Power				Based on Design Altitude Power		
			4		5		6	7	
Power Plant Type	T. O. PWR Rating	Altitude Degradation	Engine Weight (Lbs)		Nacelle and Accessories (Lbs)		Outrigger (Lbs)	Water Recovery Apparatus (Lbs)	
Turbine (Type 1)	110% HP NRP	HP _{S. L.} = 112% HP 5,000 = 126% HP 10,000 = 164% HP 20,000	250(10) (.0002205HP) _{NRP}		0.297 /SHP _{NRP}		375	Not Applicable	
Reciprocating Compound (Type 2)	120% HP NRP	HP _{S. L.} = 100% HP 5,000 = 106% HP 10,000 = 110% HP 20,000	1.2(BHP _{NRP}) + 200		0.743 ^{lb} /BHP _{NRP}		425	1.2 /BHP _{NRP}	
Air-Cooled Diesel (Type 3)	120% HP NRP	HP _{S. L.} = 100% HP 5,000 = 112% HP 10,000 = 118% HP 20,000	1.7(BHP _{NRP}) + 1180		0.706 ^{lb} /BHP _{NRP}		525	1.2 /BHP _{NRP}	
Air-Cooled "Wankel" (Type 4)	120% HP NRP	HP _{S. L.} = 100% HP 5,000 = 106% HP 10,000 = 110% HP 20,000	1.10(BHP _{NRP}) + 185		0.656 ^{lb} /BHP _{NRP}		400	1.2 /BHP _{NRP}	

Propeller Weight = $(0.89 \text{ BHP}_{\text{NRP}})^{.8} (3.32 + .000115 \text{ h}) 10^{-.0015 V_k}$

Where h = Design Altitude in Feet

BHP_{NRP} = Horsepower at Design Altitude

V_k = Velocity in Knots at Design Altitude

Weights common to all ships, Conventional and "Dynastat":

Fixed Weights

Avionics 8,000^{lb}
Electrical 2,500^{lb}
Power Generation
Crew W/Gear (10 X 200) = 2,000^{lb}

Variable Weights

Food and Water 224^{lb} day
Fuel System (.46^{lb}/gal) .077^{lb} of fuel

TABLE A-5

DIRECT INJECTION TURBO-COMPOUND RECIPROCATING
ENGINE (WRIGHT)

% S. L. HP	B. S. F. C.			LBS/BHP/HR	
	S. L.	5,000	10,000	15,000	20,000
121.4	.729	...	...	...	...
103.5	.690	.676	...	...	...
100.0	.681	.668	...	...	...
96.4	.674	.661	...	...	...
92.9	.664	.651	.639	...	...
91.1	...	...	...	.644	.629
89.3	.654	.644	.632	.644	.628
85.7	.641	.632	.621	.606	.620
82.1	.629	.616	.605	.585	.617
78.5	.615	.600	.585	.571	.555
75.0	.593	.576	.567	.407	.398
71.4	.425	.420	.411	.402	.390
67.9	.410	.410	.403	.394	.387
64.3	.408	.400	.395	.389	.382
60.7	.405	.398	.392	.385	.380
57.1	.400	.397	.389	.383	.378
53.6	.397	.390	.387	.380	.375
50.0	.393	.386	.382	.375	.372
46.4	.391	.385	.381	.375	.373
42.8	.388	.383	.378	.375	.375
39.3	.386	.382	.382	.380	.377
35.7	.390	.390	.390	.390	.390
32.1	.398	.398	.398	.398	.398
28.6	.406	.406	.406	.406	.406

REF: ENGINEERING PROCEDURE S-017

TABLE A-6

AIR-COOLED DIESEL (CONTINENTAL)

% HP NRP	B. S. F. C. Lbs/BHP/HR All Altitudes
120	.470
115	.461
110	.452
105	.442
100	.431
95	.419
90	.406
85	.393
80	.383
75	.378
70	.377
65	.378
60	.381
55	.386
50	.393
45	.401
40	.409
35	.418
30	.428
25	.438
20	.448

REF: ENGINEERING PROCEDURE S-017

TABLE A-7

TURBO-PROP

From Reference (15)

V_k	Power rating	Corresponding condition	B.S.F.C. lbs/bhp-hr.					
			Sea level	1500 ft	3000 ft	5000 ft	10,000 ft	20,000 ft
70	Take-off		.510	.506	.503	.498	.491	.485
140			.497	.492	.487	.480	.477	.471
210			.481	.478	.475	.471	.461	.455
30-70	Military		.516	.513	.510	.506	.496	.488
140			.501	.498	.495	.491	.481	.473
210			.487	.483	.480	.475	.466	.455
30-70	Normal rated power	V_{max} N.R.P.	.527	.523	.519	.514	.504	.496
140			.511	.507	.503	.498	.488	.481
210			.495	.491	.488	.483	.472	.460
30-70	90% N.R.P.	V_{max} or $V_{max. end.}$	.544	.540	.536	.530	.518	.509
140			.527	.523	.519	.513	.502	.486
210			.510	.506	.502	.496	.485	.468
30-70	75% N.R.P.		.578	.573	.567	.560	.545	.533
140			.559	.554	.548	.541	.526	.505
210			.538	.533	.528	.522	.495	.485

REF: ENGINEERING PROCEDURE 5.017

APPENDIX B

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Figure B-1, Unit Lift of Helium	B-2
Figure B-2, Gross Lift/1,000 ft ³ Helium	B-3
Figure B-3, Gross Static Lift with Altitude	B-4
Figure B-4, Loss in Static Lift due to Humidity	B-5
Figure B-5, Gain in Sea-Level Lift with Superheat	B-6

APPENDIX B

The general rules of aerostatics are:

1. Lift of an aerostat varies with the volume if all other factors remain constant.
2. Lift of a given volume of gas increases if barometric pressure increases and vice versa.
3. Lift of a given volume of gas decreases if atmospheric temperature increases and vice versa.
4. The higher the atmospheric humidity the less the lift.
5. There is no change in equilibrium if the gas is free to change its volume and if the gas and air temperatures and pressures change by like amounts.
6. An aerostat in equilibrium at one altitude will be in equilibrium at any other altitude, providing no weight is lost or gained and the superheat value is not changed.
7. Barometric pressure will decrease about one (1) inch for every 1000 ft of ascent in the lower atmosphere.
8. Atmospheric temperature will decrease approximately 1 deg F for every 300 ft of ascent, or $3\frac{1}{3}$ deg for every 1000 ft ascent.
9. Gas volume and density are each changed, but oppositely, about 1 percent for every 5 deg F change in gas temperature, at constant pressure.
10. Lift is changed about 1 percent for each 5 deg F difference in temperature between gas and air if the gas is free to expand but below the pressure height of the aerostat.

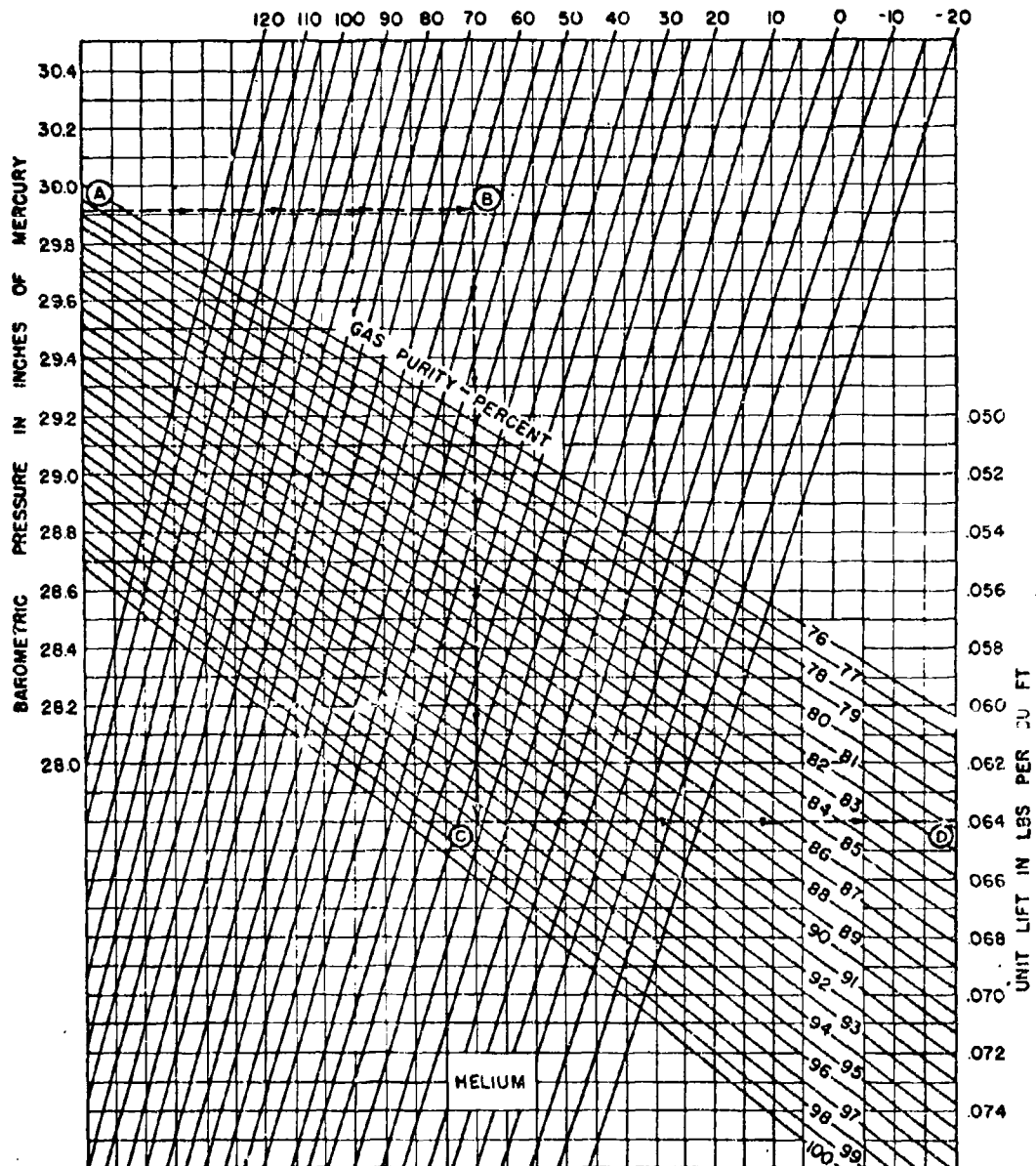
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FIGURE B-1

UNIT LIFT OF HELIUM

TEMPERATURE IN DEGREES F

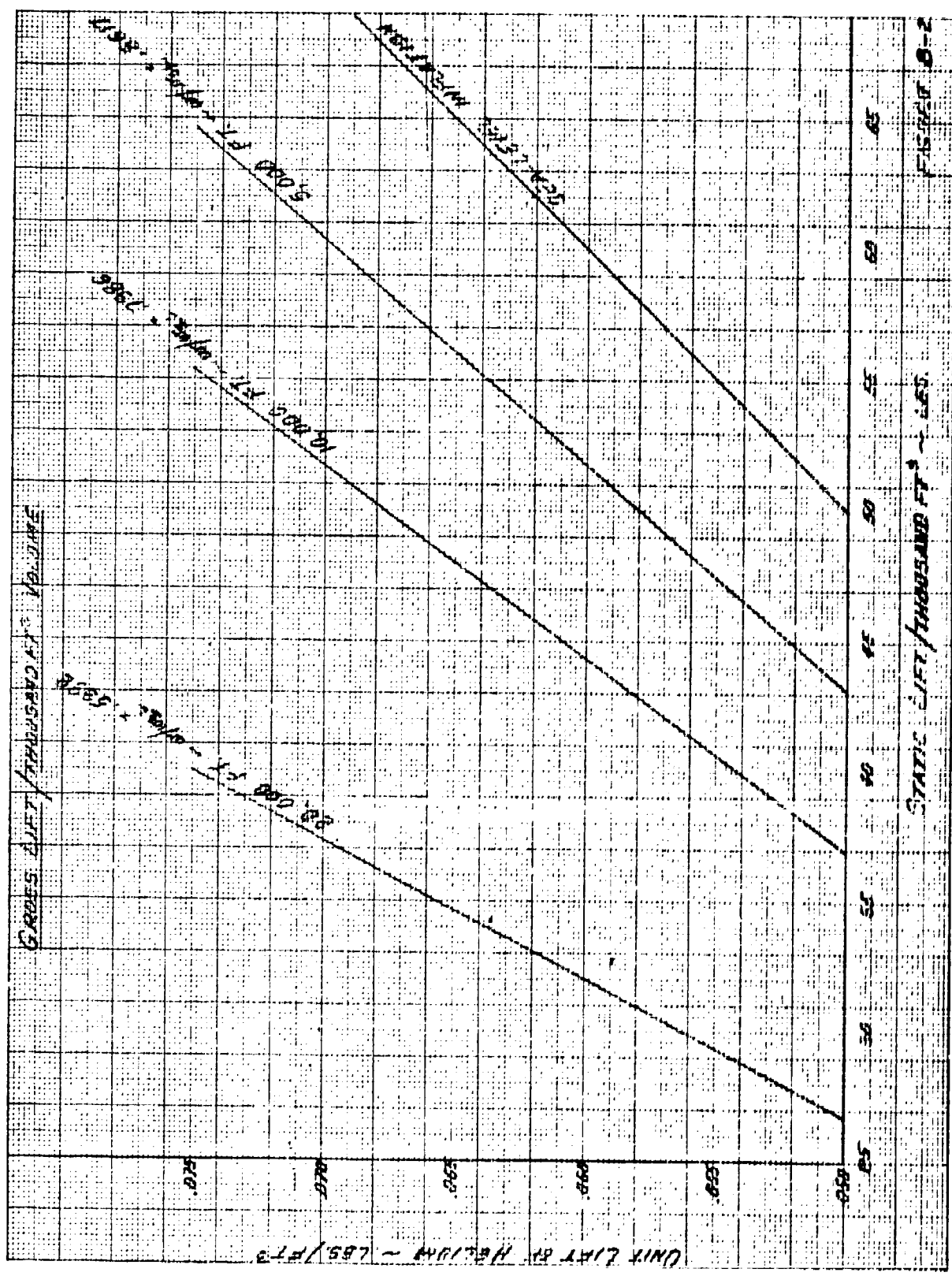


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GOODYEAR AEROSPACE

H-3

13-14



GROSS LIFT / THOUSAND FT3 VALUE

STATIC LIFT / THOUSAND FT3 ~ LB5

UNIT LIFT AT HELIUM ~ LB5/FT3

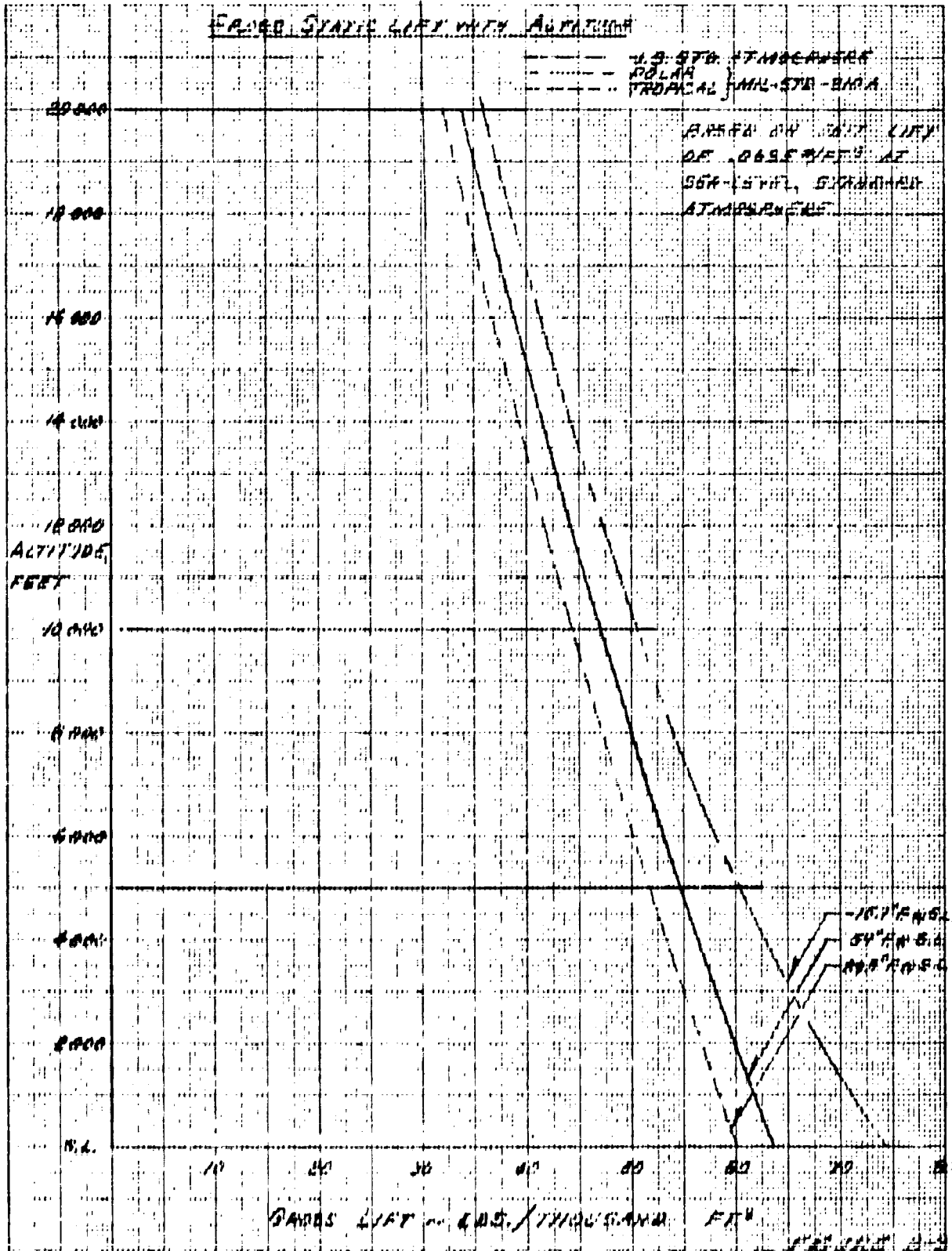
FIGURE 8-2

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GOODYEAR AEROSPACE

FIXED STATIC LIFT WITH ADAPTATION



GOODYEAR AEROSPACE

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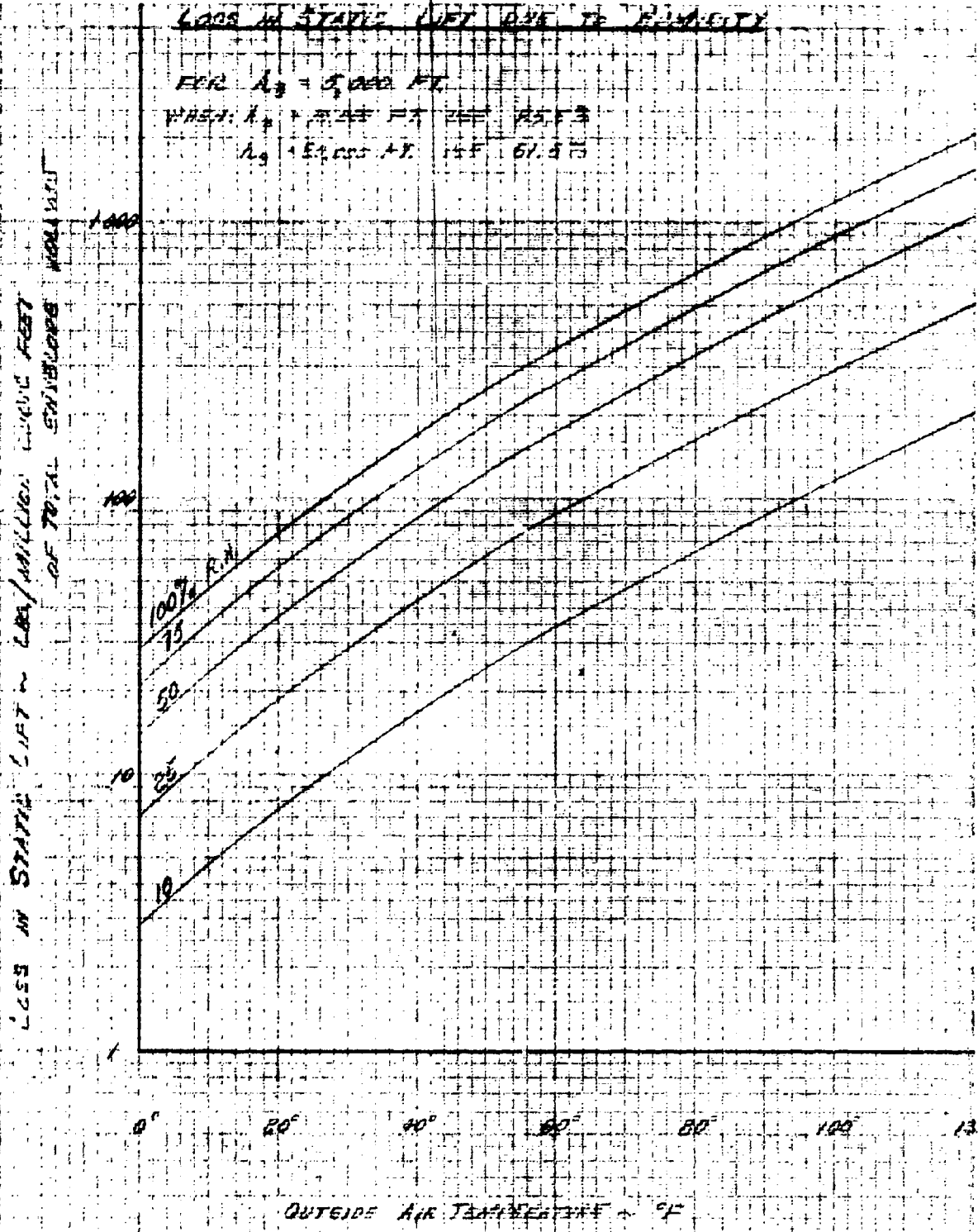


FIGURE 1-1

B C

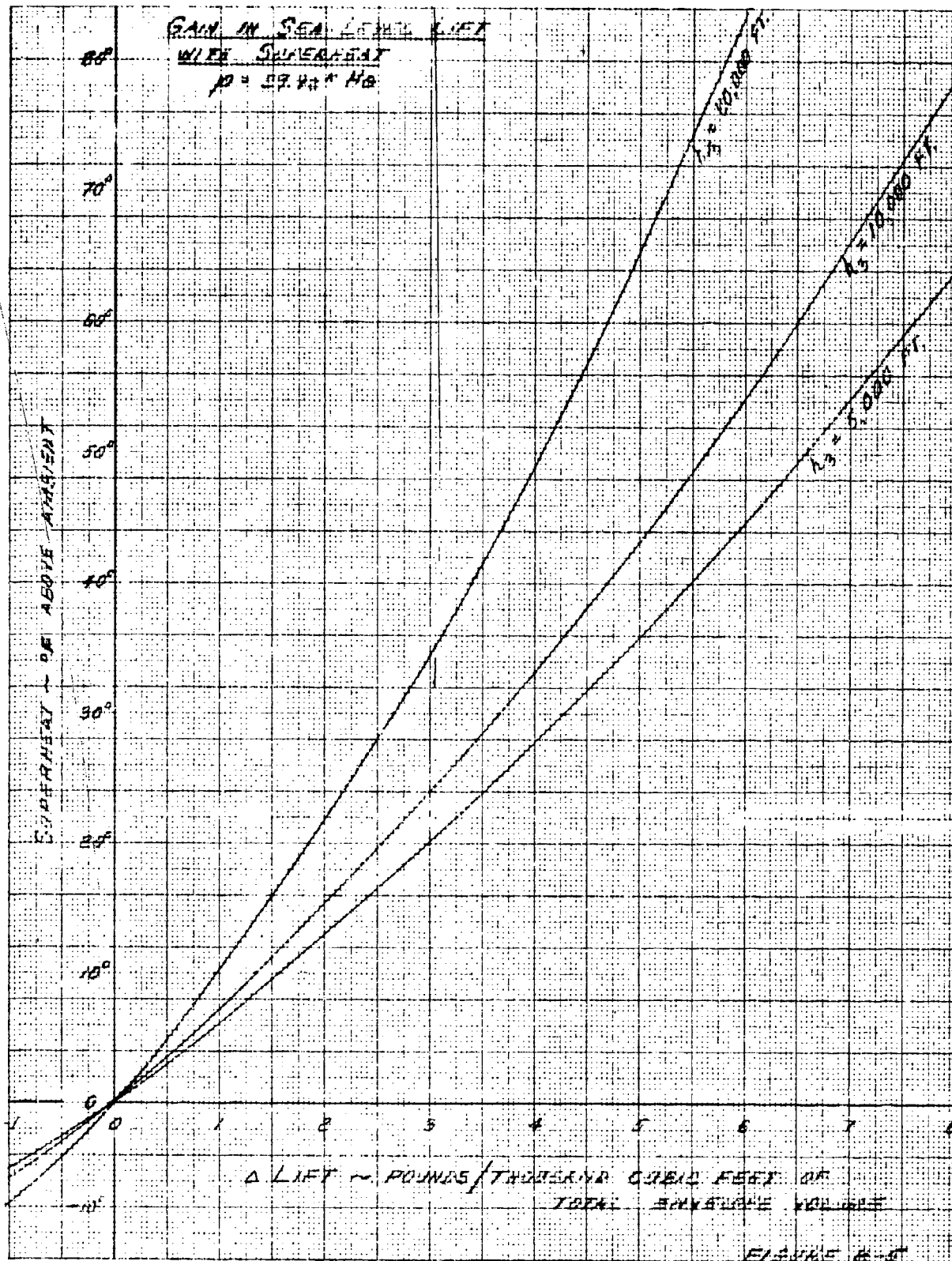


FIGURE 2-5